Pacific Coast Society of Prosthodontics Meeting, Victoria, B. C., Aug. 31 to Sept. 2, 1961.

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THE JOURNAL OF PROSTHETIC DENTISTRY

VOLUME 11 JULY-AUGUST, 1961 NUMBER 4

COMPLETE DENTURES
REMOVABLE PARTIAL DENTURES
FIXED PARTIAL DENTURES
OPERATIVE DENTISTRY

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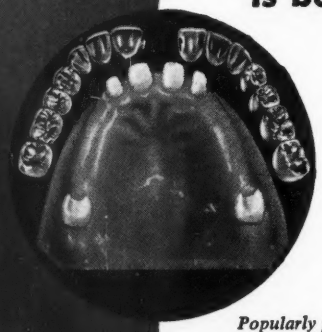

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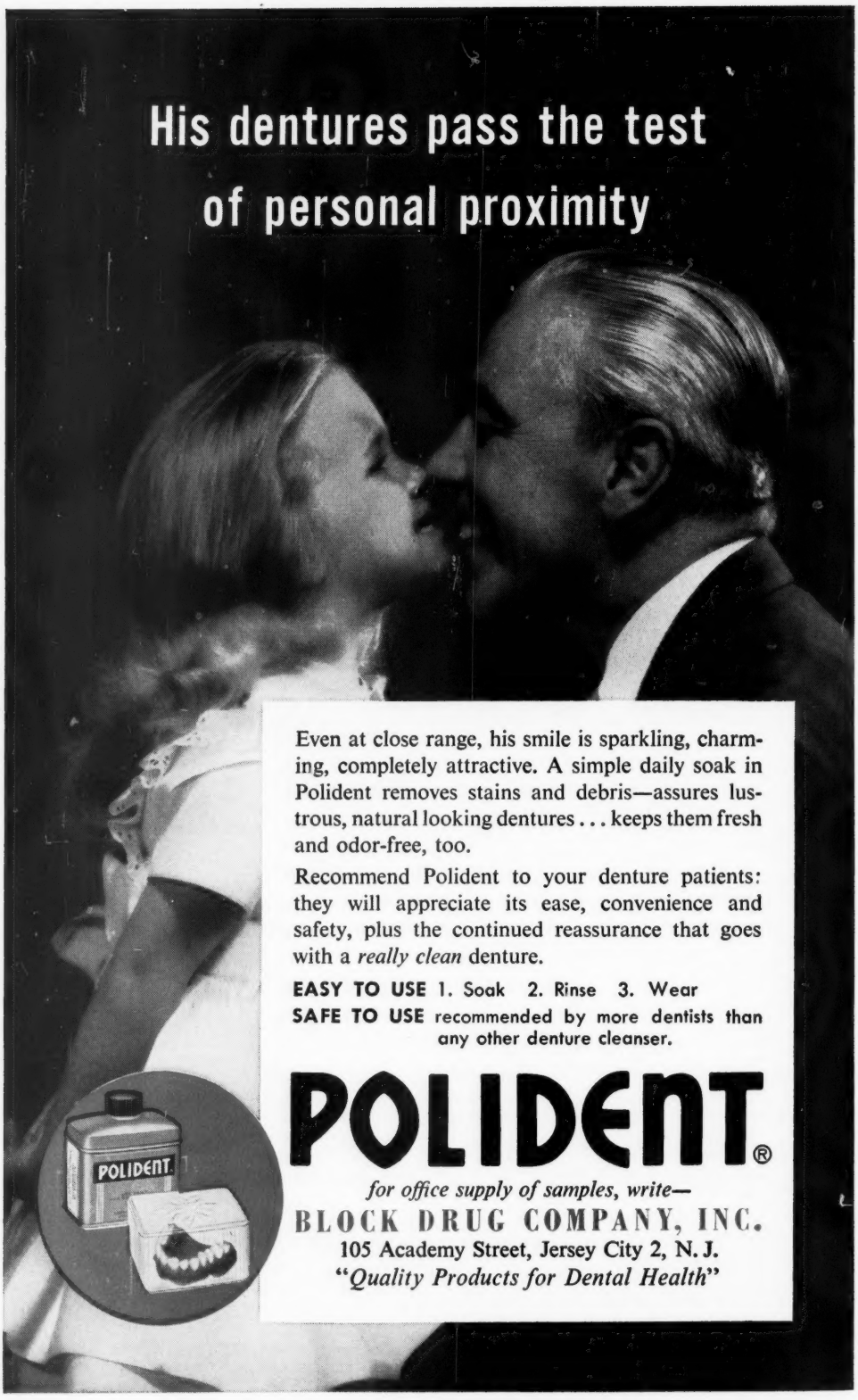

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Keith R. Marcroft, B.S., D.D.S., Raymond L. Tencate, and William W. Hurst, D.D.S., Chicago, Ill. **657**

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Complete Crown Form and the Periodontium.

Russell C. Wheeler, D.D.S., St. Louis, Mo. **722**

The functional form of the individual tooth protects the periodontal tissues and therefore helps to stabilize its position in the arch. In planning preparations, this form

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should be respected, and no more tooth structure should be removed than that which can be restored to normal function. Especially is this true of the cervical third of crowns and of roots.

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OPERATIVE DENTISTRY

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Isaac V. Gerson, D.D.S., D.M.D., Brookline, Mass. **749**

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Harold E. Schnepper, D.M.D., M.S., and Lloyd Baum, D.M.D., M.S., College of Medical Evangelists, School of Dentistry, Loma Linda, Calif. **772**

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Harry M. Bohannan, A.B., D.M.D., and Leonard Abrams, D.D.S., Seattle, Wash., and Philadelphia, Pa. **781**

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Maxillofacial Prosthetics.

Jerome C. Strain, D.D.S., University of California, School of Dentistry, San Francisco, Calif. **790**

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Vol. 11, No. 4, July-August, 1961. The Journal of Prosthetic Dentistry is published by The C. V. Mosby Company, 3207 Washington Blvd., St. Louis 3, Mo. Subscription rates: United States, its possessions, and Canada $12.00; Latin America and Spain $13.00; other countries $13.50. Students and dentists on residency programs: United States, its possessions, and Canada, $7.20; Latin America and Spain $8.20; other countries $8.70. Single copies $2.50 postpaid. Second class postage paid at St. Louis, Mo., and at additional offices. Printed in the U.S.A. Copyright © 1961 by The C. V. Mosby Company.

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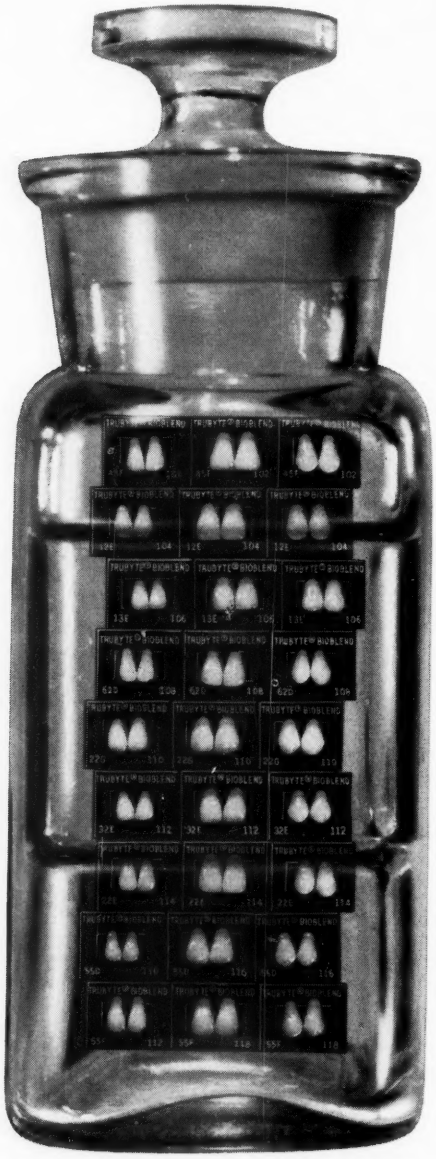

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THE JOURNAL OF
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JULY-
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NUMBER 4

THROUGH THE EYES OF THE EDITOR

Michael J. Walsh discusses the nutritional problems relating to denture patients. He points out that the problems probably exist before the patients lose the teeth and that the loss of teeth complicates them. Not all denture failures result from the mechanical phase of denture service. Adequate consideration must be given to the well-being of the patient as a whole. He suggests office procedures and techniques which should aid the over-all treatment.

Henry A. Collett discusses the psychologic conditioning of denture patients and explains why some patients react to dentures the way they do. He indicates that there is no precise method for handling each patient and that the key to successful psychologic control may involve concealing from the patient the dentist's reactions to him. If the background for creating a more receptive mood relating to dentures is understood, the rapport between the dentist and his patient will be more easily achieved. Each dentist must develop his own techniques for getting his patients in the proper frame of mind regarding dentures.

Edward V. Zegarelli, Austin H. Kutscher, Robert E. Herlands, John J. Lucca, and Herbert F. Silvers report the results of different methods for treating patients with some form of denture stomatitis. They state that a thorough examination of the mouth and a critical evaluation of the dentures are prerequisites to therapy. They emphasize the importance of selecting the right therapeutic agent to treat each lesion.

W. Ross Stromberg suggests the use of vibration as a means for developing an equalized contact in centric and eccentric occlusion. He uses an abrasive paste on the teeth while a hand vibrator is held against the chin. He also uses this method to detect deflective occlusal contacts. The vibration permits the patient to "feel" the first tooth contacts. He warns that excessive grinding in this manner will unbalance the occlusion, so that care must be used with the technique.

Jerome M. Schweitzer reports his extensive studies of masticatory function in man. He used many techniques in the attempts to determine exactly what happens when a person chews food, and he points out some possible sources of error in these research techniques. He concludes that much basic research is still needed before a complete understanding of the function of mastication is possible. The techniques he used suggest other procedures for studying the problem. When the problem is solved, the choice of an articulator and tooth forms should be on a more sound basis than it is now.

Conrad C. Bennett describes his technique for making immediate dentures. He makes full use of diagnostic casts and uses a combination rubber-base impression of the soft tissues and alginate impression of the teeth. He suggests the use of a shade guide for selecting the colors to be applied to the denture base. The mouth and laboratory procedures are well coordinated.

Keith R. Marcroft, Raymond L. Tencate, and William W. Hurst describe a technique for flasking dentures which produces a smooth surface on the denture and facilitates its recovery from the flask. Their tests indicate that the procedure does not increase the vertical dimension of the denture and may even be more accurate than the usual flasking procedures.

Charles J. Stout suggests the use of infrared heat for softening old acrylic resin during the rebasing procedure. This allows all of the old resin to be removed and makes it possible to supply an entirely new base for a denture that is being refitted. The technique makes it possible to retint the denture base and make improvements over that of the original denture, and it avoids an unsightly union between different parts of the base.

Jerome C. Strain reports his studies of the materials used for coloring denture bases and sets up standards for these materials. There has been little information available about these coloring materials; this is, therefore, a timely study. He found variations in their ability to resist leaching by the action of the saliva, but he did not detect any evidence of inflammation or irritation from the coloring agents he tested.

Elam Harris discusses his concept of an ideal denture-base material and suggests that one which has an inner liner that will remain soft would be ideal. He feels that the very hardness of the materials being used causes much of the difficulty that some patients experience with dentures. The factors of curing shrinkage and warpage and changes in form as the result of subsequent water sorption do contribute to the problem. More research can lead to production of better denture-base materials.

M. M. DeVan discusses the problems patients and dentists face when patients lose the teeth and become edentulous. He recognizes differences between reactions that occur when the teeth must be lost, and he suggests means whereby the physicial and mental shock to patients can be reduced. He points out many reasons why missing teeth should be replaced, even temporarily, for patients who must become edentulous. As one solution to the problem, he suggests the use of "additive" partial dentures. These are designed so that other teeth can be added to the denture from time to time as additional teeth are lost. In this manner, the patients are prepared for wearing complete dentures. Many sensitive patients will appreciate this service.

Eugen J. Dolder describes his bar joint removable partial denture and describes the technique for its use. The procedure involves splinting teeth together by means of a high-fusing bar. The denture is constructed to fit over the bar and thus rests upon it. Retention is provided by an elastic split sleeve which springs over the bar. The attachment is similar to the old Gilmore clasp, but it is improved by alterations in the design of the bar. Modern endodontic procedures make this a more practical device than it would have been some years previously. The mechanical advantage of its use on shortened teeth offers the possibility of extending the usefulness of a few remaining natural teeth. The results he reports appear to be very good.

Clyde H. Schuyler discusses the factors that contribute to traumatic occlusion. He shows how the chewing cycle may pass beyond the centric occlusal contacts and on to the balancing inclines on the side where chewing is being done. This causes excess pressure to be applied on the balancing teeth. He suggests the reduction of the balancing inclines as a means to prevent this trauma, and he favors this procedure over that in which the occlusion is protected by the cuspid teeth. He points out the reduction of efficiency resulting from a "cuspid-protected" occlusion and the extra strain on the periodontium supporting the cuspids when these teeth prevent the posterior teeth from contacting in eccentric occlusions.

Leonard I. Linkow describes the clinical and laboratory phases of his technique for complete oral rehabilitation. He uses modeling compound impressions made in copper bands to obtain dies but ligates all of the copper bands together in the mouth (after making sure that the impressions are accurate). Then a plaster impression is made over all of them so that they will be correctly oriented in the master cast. Then, when the modeling compound impressions are copper plated, all of the copper bands are plated at the same time. The electrical connection is assured by the ligating wire. He also retains some unprepared teeth in occlusion in order to maintain the occlusal relationships.

Russell C. Wheeler discusses the relationship between the form of clinical crowns and the periodontium. He lists the requirements of the "protective form of a tooth" and points out the untoward effects of disregard for these requirements. He compares the margins of inlays with the margins of crowns and suggests that the same principles should govern the placement of each. This means that the margins of crowns should be placed at the level which would provide the best contour of the tooth for the protection of the gingivae. It is a recommendation of conservation of natural tooth structure.

Anthony La Forgia describes his procedures for making rubber-base impressions for fixed restorations and for forming the dies and casts and making jaw relation records. He uses a double mix technique for impressions and pours two casts in the impression so that the occlusion can be developed on one while the "fit" of the restorations is developed on the other.

Ernest B. Nuttall reviews some of the clinical and technical aspects of porcelain jacket crown construction and describes his procedures for meeting some difficult problems involved in making these restorations. His techniques for restoring broken teeth should be effective, provided adequate care is taken in their execution.

Isaac V. Gerson discusses restorations for anterior teeth and describes his technique for making proximal gold inlays with lingual access. The procedure avoids an undesirable display of gold and can be adapted to many situations. It is an indirect technique that involves the use of maximum separation of teeth and rubber-base impressions in trays that are made to fit the conditions of the involved tooth.

Wilmer B. Eames, Eugene W. Skinner, and Genowefa T. Mizera report their tests of the strength of amalgam with different techniques for mixing and condensation. They conclude that the alloy:mercury ratio is a most important factor and that "consistently better condensed and stronger amalgam restorations result from a wet mix than from an excessively dry mix."

Harold E. Schnepper and Lloyd Baum describe their procedure for making cast gold restorations with parallel pins for retention. The technique involves the use of a special paralleling device in order that the pinholes can be made perfectly parallel. The cavity preparation is modified so that a minimum of tooth structure is removed.

Harry M. Bohannan and Leonard Abrams suggest that vital pulps should be removed in certain situations in order that adequate periodontal rehabilitation procedures can be instituted with success. The treatment may seem to be radical, but, if it is used in the right instances, it could be the means for providing the best service for the patient. They suggest this treatment where it is necessary to establish an ideal occlusal plane, to reduce the crown:root ratio, and to establish parallelism of clinical crowns. Obviously, success with this type of therapy will depend upon good judgment and meticulous execution of the endodontic treatment.

Jerome C. Strain discusses congenital and acquired maxillofacial defects and their treatment. He reviews the etiologic background of the congenital cleft palate and suggests the types of prostheses which are useful in treatment. The choice of material and method must vary with the location and size of the anomaly. The dentist is an important part of the team which should treat these patients.

—Carl O. Boucher

COMPLETE DENTURES

SYSTEMIC CONDITIONING THROUGH BETTER NUTRITION

MICHAEL J. WALSH, SC.D., F.R.I.C., A.I.CH.E.*
Beverly Hills, Calif.

THE CLINICAL APPLICATION OF NUTRITION can be reduced to routine, everyday practice in the dental office. The benefits to the over-all health of the patient, the improvement in the effectiveness of conventional dental surgical and mechanical procedures, and the enhanced value of the professional service indicate that every dentist should add the techniques of nutrition education to the routine armamentarium of the dental office. Unfortunately, however, too few dentists take steps to deal with their patients' nutritional problems.[1]

NUTRITIONAL DEFICIENCIES

The nutritional deficiencies and metabolic handicaps afflicting the prosthodontist's patients did *not* begin shortly before they became dental patients. The probability is that the deficiencies commenced even before birth. Dietary studies on a large number of pregnant women revealed the same type of multiple vitamin, mineral, and protein deficiencies with insufficient total caloric intake. Excessive proportions of the total calories were in the form of refined, fermentable carbohydrates. These are principally the same dietary patterns so frequently indicated in dental conditions. The obstetricians reported spectacular improvement in the course and the outcome of pregnancies in women treated nutritionally as compared with previous experiences before corrective nutritional procedures were instituted.[2] Caries incidence was dramatically reduced while periodontal conditions improved even during pregnancy.

OCCURRENCE OF TOOTH DECAY

There is a well-defined relationship between the occurrence of tooth decay and the excessive consumption of refined, fermentable carbohydrates.[3,4] In most instances, however, the patient, and not the dentist, can obtain the most spectacular results in the arrest of existing decay and prevention of future decay by adhering

Read before the Academy of Denture Prosthetics in San Juan, Puerto Rico.
*Consulting Nutritionist; Instructor in Clinical Nutrition, University of California, Dental Extension.

to corrective diets. A prominent feature of corrective diets consists of restricting the excessive consumption of refined, fermentable carbohydrates and replacing these items with additional milk products, eggs, meats, seafoods, poultry, fruits, and vegetables. In most instances in which caries is not arrested, either the patient does not follow the dentist's advice on nutrition or the dentist does not instruct the patient concerning the principles of good nutrition. Thus, recurrent decay is the rule rather than the exception. The dentist who fails to prescribe corrective diets for the prevention of tooth decay fails to put the young patient on the road to over-all health (including dental health) for adult life.

The diets which the dentist can prescribe for preventing tooth decay are those which also promote general good health and well-being. For example, the same type of menus which I formulated 25 years ago for the prevention of tooth decay have since been used successfully for young patients with orthodontic, poliomyelitic, eye, ear, nose, throat, and allergic disturbances.[5,6] The same corrective diets at different caloric and protein levels have been used successfully among adult patients with degenerative disease and periodontal, prosthetic, and even psychiatric problems.[7,8]

NUTRITION IN ORTHODONTICS

Dental ill health is carried a stage further in early life if the patient also happens to need orthodontic treatment. An orthodontic problem develops because of delayed growth and differentiation in the child. Hence, the essence of the orthodontist's dilemma is how to hasten biologic growth so that, within the interval of 2 to 3 years, the patient can accomplish 7 to 9 years of growth. Of course, this is a physiologic impossibility according to our limited knowledge. Nevertheless, it is amazing how effectively good nutrition can accelerate the biologic growth and development of the child. In addition, optimal diets for orthodontic conditions have other benefits. Orthodontic corrective diets are also caries-preventive diets. Hence, the risk of developing cavities under bands and braces is minimized during orthodontic procedures. Orthodontic corrective diets also reduce the danger of root resorption, thus avoiding periodontal involvement in later life.

NUTRITION IN PERIODONTICS

The application of nutrition to periodontics gives the dentist his greatest challenge and opportunity to make progress. Oral hygiene, scaling, correction of malocclusion, elimination of pockets, and gingival surgical operation are procedures that are more important than ever. However, the application of nutrition changes the whole picture.

Until now, dentistry has been a one way street. Now, periodontics makes possible the arrest of the degenerative processes and the avoidance of future pathologic conditions. It is probably during the period of life when periodontal disease occurs most frequently that the greatest acceleration in the degenerative processes takes place.

The Periodontal Problem.—In every tissue cell, there are relationships between cytoblastic and cytoclastic activity, anabolic and catabolic processes, and osteo-

blastic and osteoclastic activity—the building up and breaking down processes. When the rate of spending, deterioration, or degeneration of the tissue is greater than the rate of replenishment or regeneration, net depletion of the tissue results. The many names of degenerative diseases (including periodontal disease) are nothing more than labels for the consequence of excessive expenditure over replenishment.

In the nutritional management of the periodontal problem, the dentist must determine that the input of nutrients is greater than the output. Also, he must ensure that the food in the corrective diet is digested and the nutrients absorbed and metabolized. Psychosomatic factors frequently complicate this part of the picture.

NUTRITION IN PROSTHODONTICS

Nutritional problems still must be solved when the patient is faced with full extractions and complete dentures. The degenerative processes which initiated the loss of the teeth continue after extraction and cause further shrinkage of supporting tissues. The dentist trained in nutrition can do much to offset repeated relining, rebasing, and rebuilding of dentures and make the patient happier and healthier by following some simple procedures: (1) before surgical intervention, saturate the patient with therapeutic dosages of vitamins and minerals; (2) during the preoperative and postoperative periods, use scientifically evaluated liquid and semisolid diets containing the maximum quantities of nutrients within the minimum number of calories; (3) thereafter, keep the patient on a high protein, high vitamin, high mineral diet.

OFFICE PROCEDURES AND TECHNIQUES

The first requirement in the practical application of nutrition is to determine what the individual patient eats. This is done quite simply by asking the patient about his food habits and by having him make a list of every food item and drink consumed for a given interval, e.g., 1 week.[9]

The quantities of nutrients contained in the food consumed are calculated by reference to tables of food values of commonly used foods. (Excellent compilations of the nutritive value of foods are available.) Then, an estimate is made of the patient's nutritive needs by correlating his age, sex, physical activity, etc., with the known data concerning calorie, protein, vitamin, and mineral needs.

A comparison between the patient's intake of nutrients contained in the food consumed and the estimate of his needs provides an index of the degree of dietary deficiencies and imbalance in the diet.

Corrective menus are designed to furnish the nutritive needs of the patient within his caloric capacity and according to the available foods.[10,11]

RECOMMENDATIONS TO THE DENTIST

The dentist must make up his mind that nutrition is important and do something about it by starting with himself. He should solve his own nutritional problem and improve his own diet.

The dentist should widen his knowledge of nutrition through study, postgraduate courses, seminars, and local study clubs. He then must have the courage to incorporate this knowledge into the treatment of his patients.

SUMMARY

The metabolic handicaps affecting the dental patient, if ignored, rise to plague the prosthodontist. If they are considered and corrected, the prosthetic end result is enhanced while the over-all health and well-being of the patient are improved.

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BACKGROUND FOR PSYCHOLOGIC CONDITIONING OF THE DENTURE PATIENT

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THE DENTIST IS concerned with the emotional state of patients for a number of reasons.[1] First, this condition is one of the components of treatment. Second, the complete success or failure of his work often depends on this emotional state.

Some patients have extreme difficulty in adjusting to prosthetic replacements. This maladjustment seems to have a negative as well as a positive direction.

Some patients will wear dentures that are unsatisfactory from a dental point of view. They overadapt[2] to the restorations, which causes measurable damage to the supporting structures. They will not seek denture service even when it is extremely necessary.

Other patients find great difficulty in adjusting to dentures that are entirely satisfactory from a dental point of view.[3] This reaction is abnormal because the response of the patient is not appropriate to the physical situation.

Somewhere in between these two extremes are found the normal patients. The difference between a normal and an abnormal reaction is one of degree, with no sharp, definite line separating one from the other.

MALADJUSTIVE REACTIONS IN NORMAL PATIENTS

Even the Rock of Gibraltar can be destroyed by an atom or hydrogen bomb of sufficient magnitude. Likewise, the strongest individual can be destroyed or at least made to react unsatisfactorily if subjected to sufficient pressure. The communists have proved this time and again with their brain-washing techniques.

When there is an unsatisfactory reaction to dentures, the first thing the dentist must do is eliminate the possibility that they are inaccurate to the extent that the average patient would not tolerate them. One patient for whom a chrome-cobalt removable partial denture was constructed complained of a salty taste and, at first, salivation, then a dry mouth after he had worn the denture for a short time. No irritation or any factor that would seem to indicate allergy could be found. However, some of the mouth preparations were made of gold. The denture was reconstructed of gold, and he had no further difficulties. Possibly, he had a faradic reaction to the dissimilar metals. This patient might have been mis-

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Presented before the Academy of Denture Prosthetics in San Juan, Puerto Rico.

The opinions or assertions contained in this article are the private ones of the author and are not to be construed as official or reflecting the views of the Navy Department or the naval service at large.

diagnosed as a psychologic failure since he eventually refused to wear the original chrome-cobalt replacement. Neurotic reactions can be stimulated by improperly constructed dentures in patients who might react normally to satisfactory dentures.[4,5]

There seems to be a capacity beyond which there is a spillover of symptoms of maladjustment, like adding to a tumbler of water that is filled to overflowing. Some of the water becomes displaced and runs over the edge of the tumbler. One patient could wear either the complete maxillary or the mandibular denture without gagging. However, when he attempted to wear both dentures together, he gagged and had to remove them. It was found that the vertical dimension of occlusion was too great. New dentures were constructed, and he was able to get along fairly well. The incorrect vertical opening caused the psychologic overflow.

Another patient gagged after wearing a mandibular removable partial denture for 1 hour. He had just married and had problems at home. The patient had been assigned a job that was beneath his intelligence and could accomplish an entire day's work in an hour or two. Then he became bored. His job was changed to one that was more commensurate with his intelligence, and he stopped gagging when he wore the denture.[3] Everything added together was more than the tumbler could hold. However, relief of just one of the frustrating situations left enough room in the emotional tumbler for all the rest.

Subnormal oral or general health may lessen the capacity. Consultation with the physician helps rule out lack of tolerance to a denture because of a systemic problem.

DEVELOPMENT OF DENTAL ATTITUDES IN GENERAL

Some early experiences remain with us vividly in the development of our personality. Others become lost through the mechanism of repression. Association with psychologically painful stimuli often reactivates old anxieties. Dental treatment can be the painful stimulus that reactivates these repressed, psychologically traumatic experiences. Examples of this reactivation are observed in patients who overact to any phase of dental treatment.

The patient has developed certain attitudes and preconceived notions as to the treatment process before he enters the office. These feelings, related to his own previous experience, his own personality, and the hearsay of others prepare him for his dental experience. The attitudes and experiences of his family in relation to dentistry are extremely important in determining whether he will react with anxiety to the prospect of dental treatment and just how emotionally disturbed and uncooperative he will be in the chair. The patient comes conditioned to respond with tension and fear primarily because of the manner in which dentistry has been presented to him outside of the dental office, usually in his home.[6]

Dental offices, with their strange, unfamiliar, and perhaps frightening pieces of apparatus, the white coats, and the meticulous, sterile cleanliness all contribute to the feelings the patient experiences. Our relationships with the patient are also extremely important, for they help to determine the course of treatment as well as his future attempts at seeking treatment.

THE MOUTH AS AN INSTRUMENT OF EXPRESSION

The mouth takes on a specific meaning to the child in his efforts at survival. The earliest functions centering around the mouth are aimed at self-preservation. Later the mouth becomes an instrument of expression. We even call the muscles that help to make up the mouth muscles of expression.

The muscles of expression have a secondary insertion in the dental structures. The muscles are supported by the teeth, the alveolus, etc. If this support is taken away by extraction of the teeth and loss of other supporting structures, the muscles of expression no longer function in the same manner as they did when they were adequately supported. Then the patient cannot bring about a desired reaction from those about him.

Picture the Metro-Goldwyn-Mayer trademark lion roaring without teeth and with caved-in lips. The reaction of those watching would be one of comedy rather than fear. Similar reactions are stimulated in the associates of our patients if they are unable to project or express their emotions because of the loss of this supplementary insertion of the muscles of expression. This could be extremely frustrating and result in maladjustment to dentures.

DEVELOPMENT OF MALADJUSTIVE ATTITUDES

Maladjustment to dentures of a greater magnitude than might be expected from the average patient sometimes has its basis in the patient's attitudes toward his parents and others who attended his basic needs during the formative years. If the parents rejected him as a child or if he felt rejected (as for example, when a new sibling arrived and received most of the attention), the patient is likely to be fearful and insecure. This insecurity seems to be derived from the necessity for the parents to supply the basic needs such as food, clothing, and shelter. The anxiety is based on the premise that he may not get these necessities because some of the attention he formerly enjoyed is now going to the new arrival. Consequently, the patient may develop attention-seeking devices which become deeply embedded into his personality, and he is likely to use them throughout his life. If the patient does not get this much needed attention, he is likely to evaluate his environment as an insecure and hostile place. In many instances, aggressive reactions occur when this unsatisfiable need is frustrated. Denture maladjustment has excellent possibilities as an attention-getting device.

The patient obtains a certain amount of attention from the dentist by seeking unnecessary denture adjustments. The various inconveniences to which he is supposedly subjected because of dentures which are unsatisfactory to him bring attention and sympathy from family and friends, often at the expense of the reputation of the dentist.

Some patients who have an exaggerated need for attention find punishment in the form of scolding more satisfying than being ignored. They may not carry out instructions in the care and manipulation of their dentures in order to obtain this negative kind of attention not only from the dentist but from their family and friends. One patient who failed to adjust to dentures although he was outwardly cooperative during treatment said, "I am going to fight you at every turn in mak-

ing these dentures." He meant that although he would do his best to cooperate during the construction of the dentures, it was beyond his ability to control the tongue, to move the mandible to certain positions, etc. In private life, he supplemented his strong need for attention through his hobbies—a good positive outlet. He dressed as a clown to entertain children who were confined to hospitals because of illness. He was unable to wear dentures without gagging unless he chewed gum. One of his statements was, "If it gives me pleasure to gag, I will gag." There is little doubt that gagging was an attention-getting device that gave this patient a sort of perverted type of pleasure.

Maladjustments are also likely to occur if the patient's parents overprotected and pampered him. Strecker,[7] a psychiatrist, wrote an entire book on this aspect of personality development. He referred to the result as "momism." The mother watches over the child constantly, overdressing him, overmedicating him, and making up his mind for him at every opportunity. The result is a lack of confidence and a morbid dependence in later life. When this individual becomes a denture patient, he needs constant reassurance that he will be able to use the denture, that the denture will not do harm to his mouth, and that he will not hurt the dentures. This constant reassurance is a basic need of the individual which often becomes a claim on the dentist. If the claim is frustrated, the dentist might look for aggressive reactions, with expression of extreme anger.

Another picture might be painted when an individual has had a serious illness in childhood that enabled him to avoid unpleasant situations and at the same time to gain more affection and attention. Pavlov conditioned dogs to associate pleasant and unpleasant situations with bells of different tones. Later, the dogs would react physiologically to the bells alone, although they were dissociated from their meaning. For instance, if the dog was conditioned to a tasty morsel of food associated with a bell of a certain tone, he would salivate when the bell was rung in the absence of the food. Pavlov called this a conditioned reflex. The patient who avoids stressful situations and attracts affection and attention with his illness might become conditioned to this pleasant situation and in later life avoid stressful situations with a psychosomatic illness.[8] He is secondarily rewarded with the extra attention he attracts in what could be called a socially acceptable manner.

Every time a certain patient was faced with a particularly trying situation in his profession, he would require an adjustment of his complete dentures. From a dental point of view, an adjustment was not needed. The dentures were taken to the laboratory and placed in ice water for 10 to 15 minutes. Invariably, when he was returned the cold dentures which had not been adjusted, he would say that they felt much better, and we would not see him for another 2 to 3 weeks, after he was probably confronted with another frustrating problem. There is little doubt that if this patient ever became psychologically completely adjusted to his dentures, he would develop a psychosomatic illness and escape frustrations in the office of his physician.

The individual's attitudes toward authority are developed in the formative years by his relationship with those who are the environmental authority, usually the father and mother. According to our culture, the father is supposed to be the authority in the home, with the mother as sort of a secondary authority.

Because of economic changes, it has been necessary in many instances for women to contribute to the income of the family. This, together with other factors, has resulted in the emancipation of women, both legally and socially. We see this illustrated by the elimination of the word "obey" from the marriage ceremony and by comedians and cartoonists who burlesque the situation. Examples are the comic strips, "Bringing Up Father" and "Blondie." In fact, the position of the father has deteriorated to such an extent that the only one who recognizes him as the head of the household is the collector of internal revenue.

This problem is confusing to the child in developing his attitudes toward authority. Culturally, he learns that the father is the head of the family, while he is not able to observe it. Instead of developing a well-defined attitude on authority, he is likely to develop a soft authority attitude which will have advantages and disadvantages. On the negative side, in a relationship where well-defined authority is necessary for efficient operation, such as certain jobs in industry or in the armed forces, this individual will likely be somewhat less desirable.

The three reactions to authority are to conform, to escape it, or to be in direct conflict with it. These reactions are learned by the child from his interpersonal relationship with those who took care of him in the formative years. Suppose, for instance, that every time the father attempts to exert his authority, either of his own volition he does not enforce it or he is not permitted to enforce it because of a dominating mother. Conversely, the father may exert or enforce authority in an arbitrary manner not accompanied by love and affection, and the child may feel he is unfairly treated. These types of formative environment are likely to develop attitudes toward authority that are maladjustive. Broken homes and orphanages can be conducive to this type of maladjustment.

In the phenomenon of emotional transference, the patient transfers his emotional attitudes from the individual for which they were originally developed to another individual. During psychotherapy, it is often considered desirable for the patient to develop this transference to his therapist. In this way, the psychiatrist is able to observe, analyze, and sometimes give the patient insight into his behavior.

This emotional transference seems to underly many of the irrational attitudes patients have toward dentists. Because of the dentist's education, standing in the community, and special knowledge concerning his immediate problem, the patient is likely to consider him an authority figure. Through the phenomenon of transference, he might then act out his attitudes toward authority in a manner that the dentist finds most annoying.

One patient came to his dentist to have a broken tooth replaced on a complete denture. He had been wearing the denture for several years. Because of tissue loss, the denture was no longer stable, neither did it have sufficient retention. The occlusal relationship was no longer in harmony with the jaw relationship. Still, this patient was completely satisfied with the denture. He said he never had any trouble, he could eat to his satisfaction, and he liked the appearance. The patient had been raised in an orphanage where he was severely punished for even slight deviations from a well-defined chalk line. Consequently, he developed a fear of authority. His method of attempting to solve his authority difficulties was to avoid authority completely. As a result, he did not seek necessary denture treatment be-

cause he wished to avoid difficulty with the dentist, whom he considered an authority figure. He did this by denying to himself that anything was wrong with the denture. It was almost like self-hypnosis, self-induced suggestive therapy, or, perhaps better, a suggestive pathologic condition.

Environmental conditions, through their power of suggestion, can bring about positive or negative hallucinatory reactions similar in nature to those engendered by the phenomenon of hypnotism. The hallucinations that are most likely to interest prosthodontists are tactile in nature. The patient might feel pain that should not exist, making him hypersensitive to a denture, or he might not feel pain that should be present from a malfunctioning restoration.

MALADJUSTIVE REACTIONS STIMULATED BY DENTURES

The efficiency of human activity is due in part to the extensive use of symbols which act as convenient shortcuts in thinking. A flag is a symbol of a country; words are symbols for objects and thoughts. Parrots and crows can form words, but since they have no symbolic meaning, the words are next to useless. Without the use of symbols, it is difficult to imagine how we could get along in or even create a civilized world.

Symbols can become misplaced in their meaning in some of our bizarre thoughts. Time travels in one direction, resulting in irreversible changes in cells and connective tissue. This is aging. Suppose a patient is attempting to repeal the laws of gravity by having the sands of time return to the upper capsule of the hourglass. This is not unusual, for in our civilization the accent is on youth. It is even difficult for someone past 40 to obtain employment without special training in a particular field.

Suppose dentures symbolize advancing age to a patient who is attempting to deny this nasty condition even to himself. The denture becomes a constant reminder of a painful situation, causing a strong conflict because of the necessity to wear it. With this undertone, is there any wonder that the patient shows maladjustive reactions? The dentist might expect unfavorable reaction to the esthetic results from these patients when they find that dentures cannot restore the irreversible changes which even a plastic surgeon could not correct.

MOTIVATION

Motives are the inner forces that drive us to action. The motives for psychologic adjustment or maladjustment to dentures seem to be based on the patient's evaluation of himself. The more secure the patient in his self-evaluation, the more likely he will be to adjust satisfactorily to dentures. Conversely, the more inadequate and inferior the patient feels, the more he will depend on defensive devices to justify or excuse his inability to adjust properly to dentures.

To be secure, our self-evaluation must be adequate to comply with our aspirations, ideals, and evaluation of other people. For instance, if our aspirations are beyond our capacities, we will constantly undermine an evaluation of ourselves. However, if we feel that we have the ability to reach our aspirations, we are likely to be psychologically well adjusted.

DEFENSE MECHANISM FOR SELF-EVALUATION

Self-evaluation is the only security we have for dealing with the world. Therefore, we develop special techniques or defense mechanisms to cushion our failures and to alleviate the feelings of guilt mobilized by them. These defense mechanisms help us maintain the feelings of personal worth and adequacy. They protect us from intolerable anxiety aroused by a threat to our self-evaluation.[9] All of us use one or more of these defense mechanisms if the threat is great enough.

Suppose a patient cannot function well with dentures because he lacks the necessary neuromuscular skill, or suppose the esthetic result he desires is unattainable. It is possible that he will feel that his worth and ability are on trial. When this happens, he will likely resort to defense mechanisms that might result in distortion of reality and in self-deception. How might we deny reality? How many of us accept the inevitability of death? We can see it happening to our friends, but not many of us picture it happening to ourselves. Still, if we look at death logically, we know it is certain. We daily deny this reality. We might ignore or deny criticism, as we often ignore things that are not compatible with our desires or wishes. In this manner, we protect ourselves from the traumatic stress that might be aroused by certain conditions.

Patients who use the device of denial in some instances overadapt to dentures. They seem to develop a negative tactile hallucination concerning the pain that should be caused by the malfitting dentures. They do not seek adequate service from the dentist. The result is usually considerable damage to the supporting tissues.

Some people enhance their feeling of importance by identifying themselves with others in a form of hero worship. The advertising industry spends millions of dollars every year attempting to mobilize this reaction. The Davy Crockett craze and the endorsement of cigarettes and other articles by celebrities are examples. This device can have a negative as well as a positive influence, especially if it is based on an undesirable model. Often, patients who have never worn dentures say that they anticipate trouble because someone they knew had trouble. One patient gagged when he attempted to wear a mandibular denture. We found that a similar condition existed when his mother attempted to wear one. This patient, because of changes that later took place in his environment, was able to wear the denture without gagging, indicating that his difficulty did not have a physiologic foundation.

Projection is transferring the blame for shortcomings to someone else. Patients who lack sufficient neuromuscular control to masticate efficiently with well-constructed dentures supported by satisfactory denture foundations might attempt to justify this lack of skill by claiming that the denture was not properly constructed. Projecting their shortcoming on the dentist reduces the tension engendered by the feelings of inferiority, mobilized by their inability to function satisfactorily with the dentures.

Rationalization is the giving of socially acceptable reasons for behavior which it is felt inwardly is not entirely acceptable socially. It involves making excuses, and it is a defense against feelings of inferiority. An alcoholic patient claimed

that the lack of dentures was all that stood between him and satisfactory employment. He was most cooperative during the construction of his dentures, until they were completed. Then he failed to keep his appointment, and the dentures could not be inserted. In this manner, the patient temporarily avoided the anxiety that might have been engendered and the self-devaluation that might have resulted if he failed to obtain employment while wearing dentures. Not having dentures was a socially acceptable reason for unemployment to this individual.

CONCLUSION

Psychologic conditioning is far from an exact science. The dentist cannot say, "Do this or do that, and we will build a satisfactory rapport." A positive or negative rapport depends on how well the dentist's own personality harmonizes or clashes with those of his patients. Rapport often depends on how well he conceals his own reactions when he thinks the patient is being unfair. It is sometimes difficult not to think a patient is being arbitrary, especially when the dentist has done everything in his power and, from his point of view, has obtained an excellent result. If, when the patient tells him the work is no good, the dentist reacts unfavorably, the patient becomes angry; the dentist then becomes more angry, and so a vicious cycle is started that can result in nothing but failure. An objective approach to this type of maladjustment seems to be part of the answer. While there is no exact technique for handling these reactions, if it is recognized that they are based on a background of motivating forces over which the dentist has little control, he will not feel that his personal worth is on trial when he is confronted with a maladjustive reaction to dentures.

After understanding the background, handling the situation might be compared to esthetics in denture construction. The dentist can learn certain mechanics, but the real fineness of the art emanates from talents within himself. Therefore, techniques for psychologic conditioning cannot be given, merely a foundation upon which to build those techniques.

Many a good tune in music has been played by ear. In fact, a talented musician might be expected to play better by ear than one not so talented might be expected to play with music. So it is with this phase of dentistry. Some dentists have had excellent results while playing by ear. However, the talented musician might also be expected to give an even better performance if he has learned the fundamentals of harmony and composition.

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ORAL LESIONS OF INTEREST TO THE PROSTHODONTIST

Part I. Denture Stomatitis

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A NUMBER OF ETIOLOGIC FACTORS have been implicated as having either a predisposing or precipitating association with denture stomatitis. Some of these established factors are traumatic influences of the denture, vitamin B deficiency, allergy to or toxicity from denture materials, and harboring of infectious agents by the denture. Undoubtedly, there must be other causes, since a few lesions of denture stomatitis are not easily explained on any of the suggested etiologic bases and therefore are referred to as idiopathic.

This study reports an evaluation of the efficacy of certain therapeutic regimens which may be of aid in the treatment of denture stomatitis. These evaluations may contribute to the clarification of the role each etiologic factor plays in denture stomatitis.

Denture stomatitis causes an inflammatory lesion involving those soft tissues which are in immediate contact with a removable denture. This stomatitis is generally widespread, and the tissue is beefy or glistening red in color and slightly swollen, with a slimy surface. The inflamed lesion often exhibits sharp, well-demarcated borders which are limited by the denture itself.

Occasionally, lesions of denture stomatitis include small reddened, papilla-like projections. However, these are not essential for the diagnosis of denture stomatitis.

Subjectively, the lesions may be asymptomatic. Frequently, the patient is totally unaware of the existence of denture stomatitis in spite of the likelihood that it has been present for several years.

EXPERIMENTAL PROCEDURES AND OBSERVATIONS

Four men and 24 women ranging in age from 13 to 72 years were included in this study. Each subject had classic signs of denture stomatitis.

Detailed histories were obtained from all patients. No attempt was made to balance the occlusion or to adjust, reline, or otherwise alter the existent dentures prior to the completion of experimental therapy, although in many instances denture imperfections were readily apparent.

Smear specimens were obtained for culture purposes from the lesions of 24 subjects. The smears were used to inoculate Pagano-Levin medium[1] in tubes in

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order to ascertain the presence or absence of *Candida albicans* organisms. Thereafter, all patients were instructed to clean their dentures as thoroughly as possible.

TREATMENT METHODS AND RESULTS

One or more regimens were prescribed and instituted for each patient. Follow-up observations were made once or twice weekly. Response to therapy was evaluated on the basis of objective improvement of the lesion, particularly in regard to lessening of the redness.

Observation Only.—No definitive therapy was instituted for 10 subjects aside from maintenance of good hygiene at home. The subjects were observed for periods ranging from several days to several weeks. In no instance was a significant subjective or objective change noted during this control period.

Removal of Dentures.—Denture wearing was discontinued for 5 subjects for periods of 1 to 2 weeks. Complete disappearance of denture stomatitis was noted in 1 subject, moderate improvement in 3, and slight improvement in 1.

One might conclude from these results that denture stomatitis can usually be relieved by this procedure alone. However, such therapy can scarcely be advocated since the patient is deprived of his denture and the lesion promptly recurs when denture wearing is resumed.

Use of a Protective Denture Adhesive.—A bland denture adhesive* was used for 16 subjects for periods of 1 to 2 weeks. Complete disappearance of denture stomatitis was noted in 1 subject, moderate improvement in 2, slight improvement in 7, and no improvement in 6.

These results indicate that increased denture retention and improved denture stability are important factors in reduction of the inflammation of denture stomatitis.

Treatment With Amphotericin B.—*C. albicans* has been suggested as a specific infectious agent associated with denture stomatitis either as a primary etiologic agent or as a secondary invader. The efficacy of antifungal agents such as nystatin against *C. albicans* organisms has been reported.[2]

More recently, a new antifungal antibiotic, amphotericin B,† having a therapeutic spectrum much the same as that of nystatin, has been introduced.[3] Amphotericin B has a distinct advantage, from the viewpoint of the patient, over nystatin as a topical agent for oral use in that it has an innocuous taste when compared to the unpleasant taste of nystatin preparations.

Two per cent amphotericin B in an adhesive base was used for 12 subjects of whom cultures for *C. albicans* had proved to be positive. Treatment was generally instituted after one of the previous three procedures had been completed. Application of the fungicide was made by each subject three to four times daily and continued for a period of 1 to 2 weeks.

Complete disappearance of denture stomatitis was noted in 1 subject. Moderate improvement was noted in 10 subjects and slight improvement in 1 subject.

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*Orabase or Orahesive.
†Fungizone.

Maximal improvement was usually observed within 1 week, and no additional improvement occurred thereafter in spite of the continuation of therapy.

Follow-up observations on this group indicated that recurrences of lesions were quite frequent after amphotericin B therapy had been discontinued, probably because oral monilial infections are usually not primary but generally secondary to some other local or systemic predisposing factor. Since the predisposing factors had not been considered in the treatment plan, recurrences were to be expected. However, patients with recurrences continued to respond to repeated therapy with amphotericin B, further indicating a suppressive rather than a curative action of the medication.

Treatment With Diluted Sodium Hypochlorite.—Nine patients immersed their dentures in a diluted solution of sodium hypochlorite for two 10 minute periods each day. Then the dentures were rinsed thoroughly before reinsertion.

The denture stomatitis did not completely disappear in any of the subjects. However, moderate improvement was noted in 7 subjects, slight improvement in 2.

Treatment With Triamcinolone Acetonide.—A 0.1 per cent topically active corticosteriod, triamcinolone acetonide,[4] in an adhesive base was applied to the dentures of 6 subjects three to four times a day for periods ranging from 2 days to 2 weeks. Three of these subjects were selected for this therapy because of relative failure following other therapeutic approaches.

Complete disappearance of denture stomatitis was noted in all 6 subjects. However, such results are not permanent since the etiologic factor was not eradicated. Triamcinolone acetonide too acts as a suppressant rather than a curative agent.

DISCUSSION

Those subjects with lesions believed to be directly or indirectly associated with irritations caused by the denture were referred for prosthetic treatment at the conclusion of the tests. Drug therapy for these patients was merely adjunctive or suppressant and not conclusive or definitive treatment. Therefore, it is not suggested that drug therapy is intended to replace or supersede complete and thorough prosthetic dental care. It is further obvious that clinical evidences of denture stomatitis must be eliminated before impressions for new dentures are made or relining is done.

A thorough medical history must be obtained from patients with denture stomatitis, particularly with reference to recent antibiotic therapy. It is possible that an antibiotic may have contributed to the onset of oral moniliasis (overgrowth of *C. albicans* organisms). Discontinuance of the antibiotic if possible (in addition to antifungal therapy) is essential if regression of the denture stomatitis is to be effected.

Although vitamin therapy has been advocated for the treatment of denture stomatitis and although such a regimen may be truly beneficial, this aspect also was not included in the investigation.

Denture stomatitis may be associated with, or the result of, allergy to denture materials. Undoubtedly, a few instances of denture stomatitis have an allergic origin. However, allergic denture stomatitis is rarely observed.

SUMMARY

A study was undertaken to evaluate the efficacy of a number of different therapeutic regimens in the treatment of denture stomatitis. The therapeutic agents employed included 2 per cent amphotericin B in an adhesive base, a denture adhesive, a diluted sodium hypochlorite solution as a soaking medium, and 0.1 per cent triamcinolone acetonide in an adhesive base.

Various of these regimens of drug therapy were found to be useful, where indicated, as adjunctive aids in the management of denture stomatitis. However, the administration of drug therapy is not intended to replace or supersede complete and thorough prosthetic dental care for patients with denture stomatitis.

A thorough examination of the mouth as well as a complete evaluation of the dentures is a necessary prerequisite to any anticipated therapy. Laboratory procedures to ascertain the presence or absence of *C. albicans* organisms must also be considered essential in most instances of denture stomatitis. Finally, no single, specific drug therapy, arbitrarily selected, should be relied upon.

The authors express their gratitude to Mrs. Helene W. Kutscher and Mrs. Joan Leach for their assistance.

The Squibb Institute for Medical Research provided Fungizone in Orabase and Pagano-Levin medium for these studies.

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USE OF VIBRATION IN THE OCCLUSAL REFINEMENT OF COMPLETE DENTURES

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Equalized occlusal contact in centric occlusion is necessary to maintain the health of the denture-supporting tissues and the tissue of the temporomandibular joint. Various methods are used to accomplish this result. All methods require that the dentist have an intimate knowledge of the mechanics of establishing harmonious occlusal contact.

REFINING OCCLUSION BY VIBRATION

There is a need for a simple yet accurate method for refinement of the occlusion beyond that accomplished by usual methods. One such technique has been developed during recent months. My attention was first directed to the use of vibration in refining occlusion by a periodontist who used a small hand unit* to eliminate the last remnant of a rather obscure premature deflective occlusal contact of the natural dentition.

This method of vibration offered some possibilities for use in correcting occlusion for dentures as well, although if it was not carefully done, the result could develop into a traumatic rather than physiologic contact.

One of the first attempts at vibration was begun by Cervaris.† He had been trying to remove some deflective occlusal contacts by the usual "tap-tap" method. As the patient relaxed in his contour chair at home that evening and turned the vibrating unit on, he quickly realized that the deflective occlusal contacts were still present. The next morning, the dentist attempted to use vibration in locating and correcting the deflective occlusal contacts.

The vibration of the hand unit applies circular as well as vertical and horizontal motion. Specifically, it is a high frequency, variable, small amplitude, multidirectional, multiple rebound arc motion. The motion is produced by an electric motor with an eccentric shaft that causes a cycloid motion as it revolves. The circular component is undoubtedly helpful in muscle massage and stimulation, but, even though of small diameter, its aid in establishing centric occlusion is rather doubtful.

Read before the Academy of Denture Prosthetics, San Juan, Puerto Rico.
*Niagara Cyclo-Massage.
†A. R. Cervaris: Personal communication from Robert Hughlett, June, 1960.

Shortly after the experiments with the hand unit were done, an equilibrator* was introduced. This is a two speed, straight, vertical vibrator that uses a somewhat higher frequency vibration with a smaller amplitude.

METHODS

Equalized centric occlusion and eccentric balanced occlusion are developed by remounting the dentures on the articulator and making the occlusal corrections needed, such as proposed by Schuyler.[1] If a method similar to that described by Shanahan[2] is followed, those procedures are accomplished after using a pressure indicator paste.

The patient's head is tilted slightly backward in the headrest in a comfortable position. The dentures are inserted, and necessary adjustments are made to ensure that they are comfortable. A pressure indicator paste is used to ensure stability.

Obvious deflective occlusal contacts are found by using occlusal indicator wax and reduced. The remainder of the technique is completed either at this time or at a subsequent appointment after initial denture settling.

The patient is instructed on the procedure. Relaxed centric relation is demonstrated to the patient and then demonstrated by the patient to the dentist. The patient is cautioned that only a light tooth contact is needed and that contact will only be made as the dentist presses against the chin, causing the teeth to vibrate against each other. The depressor muscles will press slightly against the dentist's hand and will apply small force in a distal direction. The depressor muscles all have some distal displacing components to their force, while some of the elevator muscles have a strong anterior displacing force.

A coating of abrasive paste is applied to the occluding tooth surfaces. Carborundum paste is used if there are porcelain teeth on both dentures, a coarse pumice paste if there are acrylic resin teeth on both dentures, and an apatite paste if there are acrylic resin teeth on one denture and porcelain teeth on the other.[3]

The equilibrator chin rest is placed in position. Intermittent pressure is applied to the mandible with the unit set at either slow or fast speed. A strong pushing pressure *must not* be applied against the mandible. The objective is to vibrate the mandible along the physiologic arc of closure in centric relation and not to apply pressure toward centric relation as the design of the chin rest might indicate. Its design simply facilitates the ease of its use. The intermittent pressure is applied for approximately 3 minutes in centric occlusion as the patient allows the teeth barely to contact.

The patient moves the mandible slightly anteriorly as vibrations are applied to smooth the transition from centric occlusion toward protrusive position. This procedure is repeated using jaw movements toward right and left lateral positions for approximately 2 minutes in each position.

The abrasive paste is removed, and the occlusion is rechecked with occlusal indicator wax. If deflective occlusal contacts are detected by the dentist or the patient, the procedure is repeated.

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*Warwec.

Vibration grinding must be limited to a refinement grinding procedure *only*, avoiding overgrinding. Excessive grinding reduces the vertical dimension of occlusion and also the sharpness of occluding cusps. However, tooth reduction by this procedure is a slow process.

The patient taps the teeth into centric occlusion on articulating paper several times to register occlusal contact. The occlusal contacts are carefully narrowed with a small stone to reduce contact surface and to maintain cusp sharpness. Adequate sluiceways and cusp sharpness are provided, and all occluding surfaces are polished to reduce surface friction.

OBSERVATIONS

A light touch is necessary when using vibration to correct the occlusion. The instrument provides a small vibratory stroke along the physiologic arc of closure while the muscles of mastication are in a relaxed state with the mandible in centric relation. Patients can detect vibrating premature contacts that are sometimes difficult to detect otherwise, as long as light pressures are used. Heavy, elevating pressures by the dentist give the patient a false sense of bilateral occlusal balance.

Frequently repeated efforts by the patient to relax the muscles so the mandible will assume centric relation may be followed by muscle spasm or intermittent muscle tension, especially in the external pterygoid muscle. A light, slow vibration without any abrasive paste will quickly condition and relax the musculature so that centric relation can be again consistently assumed.

This technique is useful for the reduction of *minor* discrepancies only and must be preceded by gross adjustments first on the articulator and then in the mouth. This is not a cure-all for all occlusal discrepancies.

Overgrinding must be avoided. As the mandible is elevated along the physiologic arc of closure in centric relation, the deflective occlusal contact will touch first. The vibrating abrasive contact will reduce this spot only. No other surface is contacted. As this deflective occlusal contact is reduced, harmonious occlusal contact is gradually established. Further grinding is excessive.

The usual method of using abrasive paste for initial milling engenders many dangers. Displacement of the dentures on the supporting tissues as the jaw moves from one position to another is probably the greatest hazard. With the vibration technique, the mandible can be maintained in one position while the vibrations continue to reach only the deflective occlusal contact until it is removed. Deflective occlusal contacts which have been too elusive to be found in any other way have been removed by this method.

FURTHER USES

The vibration technique can be used as an added diagnostic tool in determining whether or not malocclusion exists. The patient can easily detect the deflective occlusal contact, particularly with natural teeth.

The vibrating technique can be used in making an interocclusal centric wax relation record. Soft wax rods are attached to the upper posterior teeth, and a rec-

ord of the lower teeth is made in the wax rods by causing the mandible to vibrate into centric relation. The dentures are mounted on the articulator, and the occlusion is corrected. The same procedure can be used with the wax occlusion rims. As the vibration conditioning technique is used, the patient is allowed to close the teeth slowly into centric relation.

SUMMARY

A vibration technique has been presented for the refinement of occlusion in complete dentures. The procedure is useful for refinement of occlusal contacts only, and its use should not be abused.

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MASTICATORY FUNCTION IN MAN

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THE ACT OF CHEWING must be observed to determine how a person masticates. However, this in itself is not sufficient. The actual movements of mastication must be recorded by still and motion picture photography. The records must be made into diagrams which have length, width, and depth. The fourth dimension, the time factor, should be included in some instances.

TYPES OF MANDIBULAR MOVEMENT

A human being is capable of performing two different forms of mastication. The voluntary, gliding, and rubbing motions and the movements of bruxism can be made by almost all people. For example, most can glide the mandible forward, backward, and from side to side with the teeth in contact.

These gliding movements can be produced on most articulators. However, whether these are natural, functional movements remains to be investigated. When a conventional articulator is moved, it follows its normal range of motion and is automatically closed so that the upper and lower teeth touch. The articulator is moved so that the cusps of the upper and lower teeth glide over each other in forward, backward, and side to side directions. These are movements equivalent to human voluntary movements.

Another method of chewing comprises the natural, functional chewing movements. These movements take place predominantly in a vertical direction and differ from the voluntary rubbing movements. Transographics is based upon the concept of a difference between the voluntary rubbing movements and the natural, vertical, functional chewing movements.

APPARATUS AND REQUIREMENTS

Still and motion picture photography was used in this investigation. The masticatory testing apparatus itself presented many difficulties and was changed as the study progressed (Figs. 1 and 2). Essentially, the apparatus was constructed so as not to interfere with the natural chewing act.

The subject's head was stabilized during the chewing tests. However, if the head was held too rigidly, the chewing movements would assume an artificial character. But if the head was not held rigidly enough, the chewing diagrams would contain many errors and could not be correctly superimposed.

Read before the American Denture Society, Chicago, Ill.
*Clinical Professor.

Fig. 1.—A headband and glass plate are attached by universal joints. A grid is marked on the glass plate, which is movable in three planes. The stylus is attached by bands to the lower incisors and carries a small electric light controlled by the subject. Movements of the mandible are recorded in either a dark or light room.

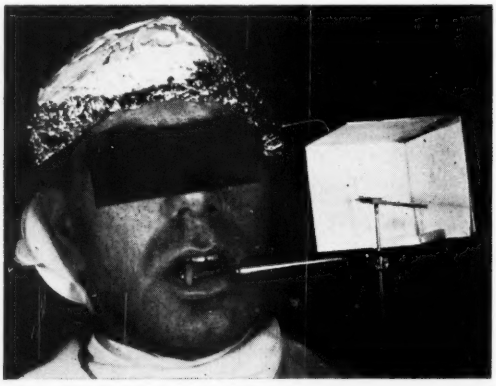


Fig. 2.—An aluminum cage is attached to the head by a metal and plaster skull cap. Records are made in three planes by a stylus that is attached to the lower incisors. The stylus writes as the chewing proceeds.

The frontal, the sagittal, and the horizontal planes of motion were registered. Reference markings were necessary to orient the tracings correctly. A fairly large sampling of patients with normal and abnormal occlusions should be selected for investigations of this type.

The idea of Christianson* was used to observe mastication from outside of the mouth. Casts of the dental arches of the subject were attached to the upper and lower teeth by means of plastic labial and buccal appliances. The casts were positioned outside of the mouth alongside the natural teeth and attached to the teeth by tubes of strong, light, rigid stainless steel (Fig. 3). When the subject chewed, the motions were seen on the casts and photographed outside of the mouth.

The best apparatus was one which was attached outside the mouth with nothing within the oral cavity to interfere with chewing. A chin cap was made of plastic

*Peter Christianson: Personal communication, May, 1958.

Fig. 3.

Fig. 4.

Fig. 3.—Plastic casts of the subject's teeth are attached outside the mouth by metal rods. Chewing movements are observed and photographed.

Fig. 4.—A plastic chin cap with a small electric light is attached by rubber cement. The chewing movements are recorded by cinephotography. Mirrors on the metal frame attached to the headrest make it possible to record three planes of movement simultaneously.

with a light or stylus attached (Fig. 4). The subject could chew naturally with the apparatus in place. The error introduced by this arrangement is the muscular movement about the chin that is independent of the masticatory strokes. Also, the distance of the stylus from the natural teeth necessitates a corrective factor for the interpretation of the exact shape of the movement figure scribed by the stylus outside the mouth as compared to that inside the mouth.

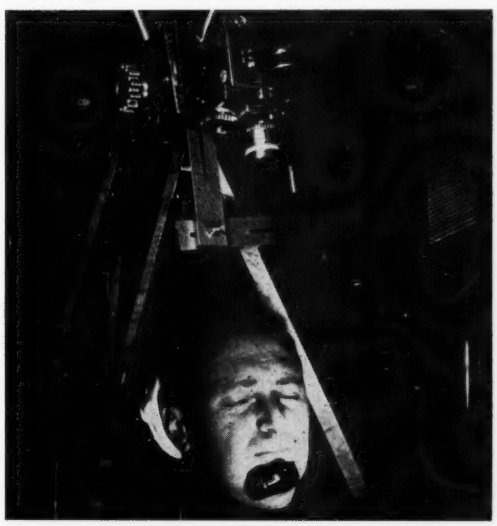
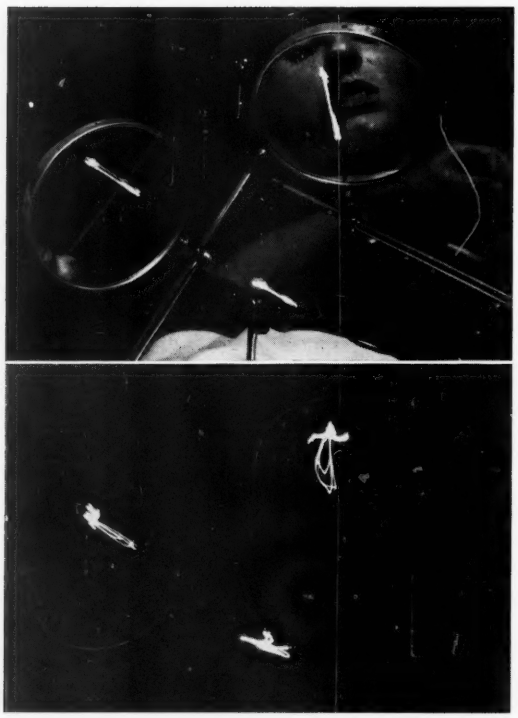


Fig. 5.—The camera is attached to a large, rigid tripod above the patient. A grid is attached as shown on the right side. The grid makes it possible to have a ruled grid appear in motion pictures of the chewing cycles. The horizontal plane is being photographed with the subject in a normal sitting posture.

A.



B.

Fig. 6.—The metal frame seen in Fig. 4 is attached to the headrest of the dental chair. The photographs are made in a dark room, using the stylus and tiny electric light attached to mandibular incisors (Figs. 1 and 4). Frontal, horizontal, and sagittal planes are photographed simultaneously by means of mirrors.

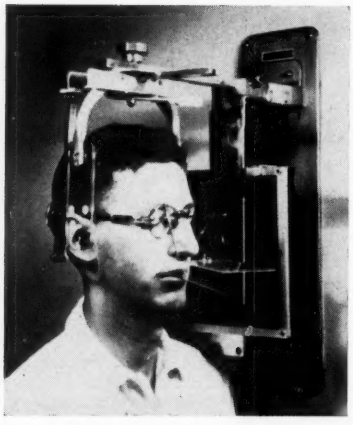


Fig. 7.—The subject's head is in a cephalostat. This method may inject inaccuracies in recording chewing movements. The eyeglass grid and rod stylus are used as the recording devices. The stylus is attached to the mandibular incisors.

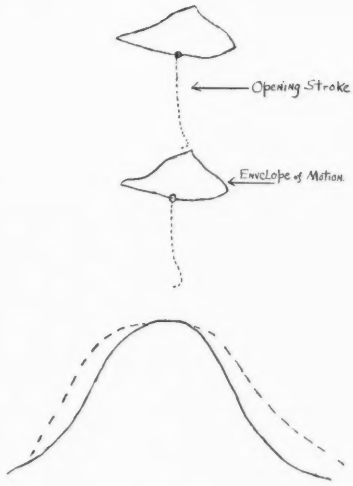


Fig. 8.

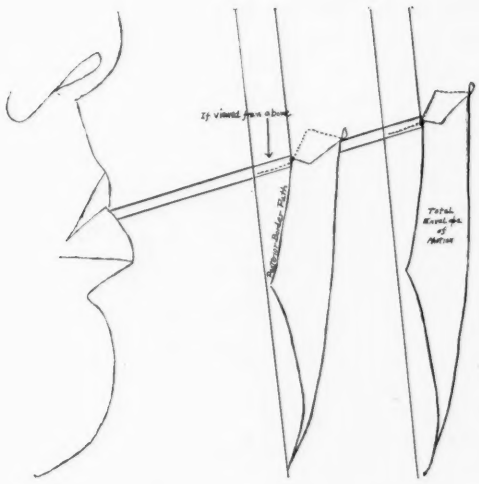


Fig. 9.

Fig. 8.—The subject makes one opening stroke. In this horizontal plane as viewed from above, the opening stroke appears to be behind the envelope of motion.

Fig. 9.—The dotted line behind the total envelope of motion in the sagittal plane represents how the posterior borderline appears when viewed from above in a horizontal projection (see Fig. 8).

Fig. 10.

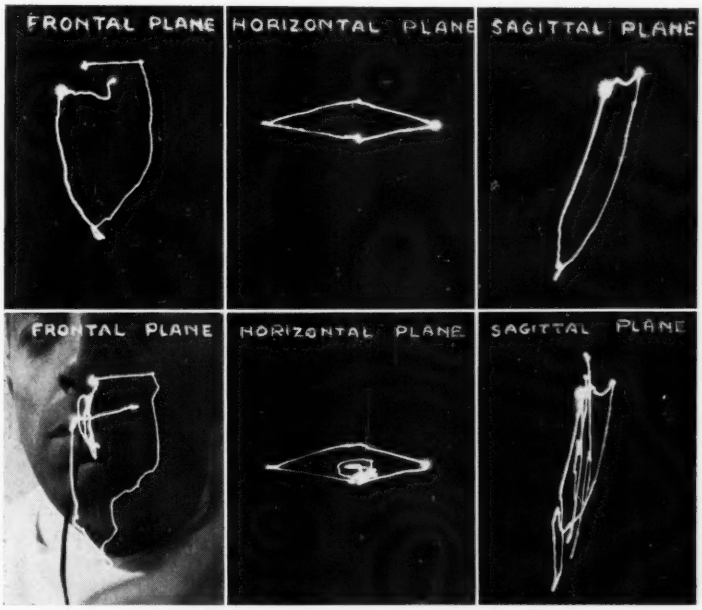


Fig. 11.

Fig. 10.—Three total envelopes of motion are made in the different planes.

Fig. 11.—The markings within the total envelopes represent the functional chewing strokes.

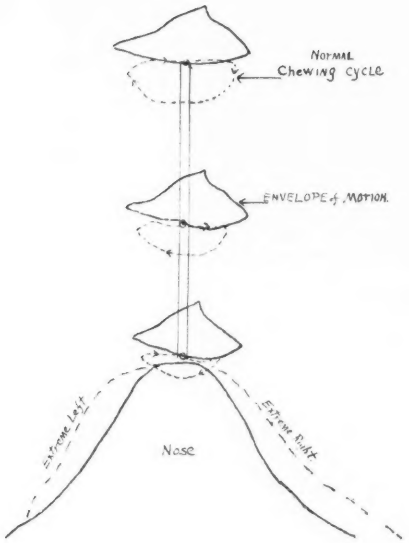


Fig. 12.

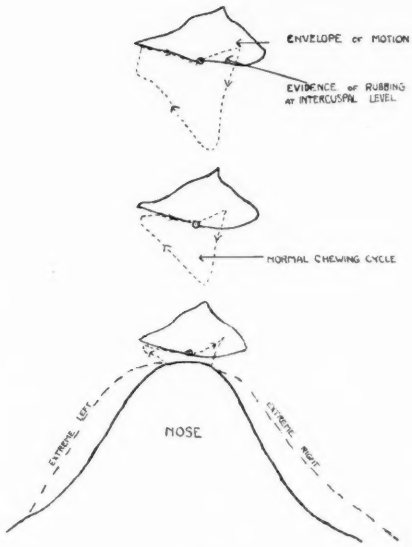


Fig. 13.

Fig. 12.—The subject is chewing a hard crust of bread. The chewing cycle appears to be behind the total envelope of motion in this horizontal projection. The entire chewing cycle took 1 3/16 seconds.

Fig. 13.—The subject is chewing a hard crust of bread and is observed from the horizontal plane. At the right side of the envelope of motion, a part of the chewing cycle appears within the envelope of movement. The total time of the cycle was 1 10/16 seconds.

REFERENCE LINES

Reference lines or points had to be established to relate movement in space to its surroundings and make it measurable. Diagrams of successive masticatory strokes could then be superimposed, and important data such as the size, speed, and time of the masticatory cycles could be obtained.

The first practical device consisted of a grid with ruled lines that was placed directly in the camera (Fig. 5). By this method, the finished motion picture had reference lines that were superimposed on the chewing strokes. The second reference grid was made of plastic and was suspended on a pair of eyeglasses (see Fig. 7). This grid could be moved in all three planes. The error introduced by movement of the eyeglasses had to be taken into consideration.

The movement of the head during mastication, including incision, chewing, and swallowing, was another unavoidable error. The head moves back in normal opening of the mouth and upward and backward during swallowing. Obstruction of these movements interferes with normal function. Both the lower and upper lips and the tip of the nose move during mastication. Therefore, these regions cannot be used as an accurate reference. It is almost impossible to use any part of the head for reference.

Motion in all three planes can be recorded simultaneously on motion picture film by the use of mirrors. However, recording in one plane at a time was found

to be more accurate. The figures in the three planes are small, and the view of the indicator can be distorted (Fig. 6). The distance of each plane from the indicator and the angle of the mirror cause distortion and a difference in the size of the separate images.

The cephalostat has also been used in making these recordings. However, the result is artificial when the head is so forcibly stabilized. The ear plugs, which are also used for stability, increase the self-consciousness of the subject and definitely interfere with chewing and mandibular movements (Fig. 7). Also, the cephalometric chair does not give the subject sufficient support during the relatively long chewing procedure.

FINDINGS

The tests indicated that no chewing strokes could be made outside the boundaries of a three dimensional figure of the total envelope of motion. Many masticating strokes *seemed* to be behind the apex of the figure when the horizontal plane was viewed from above (Figs. 8 and 12). However, this deception was recognized immediately when a sagittal view was included in the study (Figs. 9 and 14).

In geometry, an envelope "is a curve or surface which is tangent to a continuous series of curves or surfaces."[1] It was relatively easy for the subjects to make a total envelope of motion in any or all of the three planes of function, namely, the

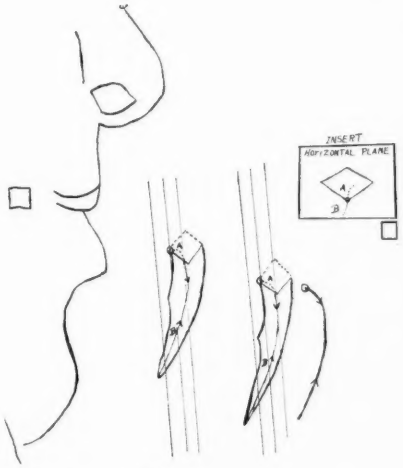


Fig. 14.

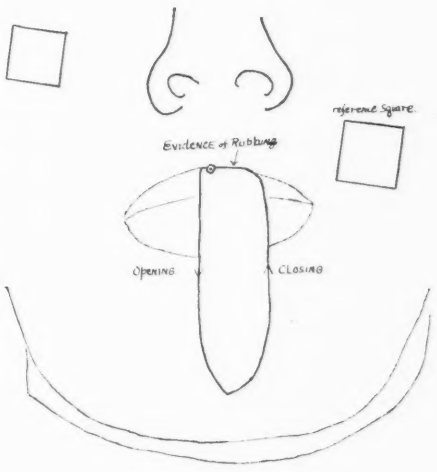


Fig. 15.

Fig. 14.—A tracing made of Fig. 28 demonstrates the crossing over of fields of function and "nonfunction." In functional movements, the mandible in the horizontal projection sometimes moves forward at the level of intercuspation into the diamond-shaped envelope of motion. An envelope of motion was drawn around the chewing strokes seen in Fig. 28. Parallel lines were made to project the chewing stroke into the horizontal plane. In the inset, *B* appears behind the wings of the seagull-shaped tracing, while *A* appears farther forward and within the diamond-shaped area. Although this envelope of motion is not accurate, it nevertheless clearly demonstrates the truth of what is shown in the main diagram.

Fig. 15.—The subject is chewing a hard crust of bread and is viewed from the frontal plane. There is evidence of rubbing at the interocclusal level. The opening time is 6/16 second. The closing time is 4/16 second. The horizontal part of the cycle required 7/16 second.

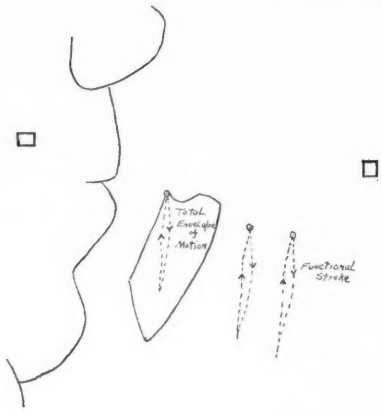


Fig. 16.

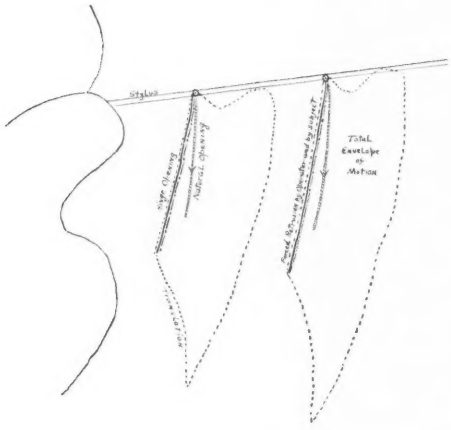


Fig. 17.

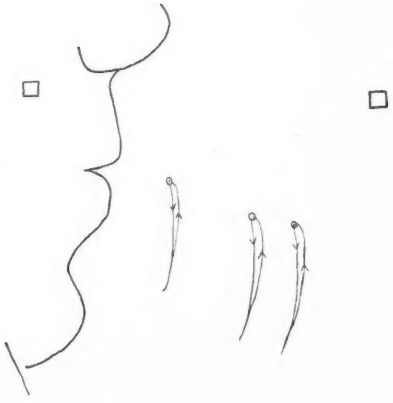


Fig. 18.

Fig. 16.—A natural opening and closing stroke. When viewed sagittally, the natural opening stroke is anterior to the closing stroke and terminates in a point with the mouth empty.

Fig. 17.—Forced retrusion by the dentist or the subject occurs along the same path. However, the natural opening stroke with the mouth empty occurs anteriorly to the posterior border path.

Fig. 18.—The first natural chewing cycle. The subject is chewing a crust of bread. The opening stroke is posterior to the closing stroke. The times required are 10/16 second for opening and 8/16 second for closing.

sagittal, the horizontal, and the frontal (Fig. 10). The boundaries of these complete envelopes of motion are border movements and are controlled mainly by nerves, bones, and ligaments. Posselt[2] has shown that a person under general anesthesia is capable of making the same total envelope of motion as he can without it. Aprile and Saizar[3] showed that a total envelope of motion can be made by moving a cadaver mandible after the muscles have been completely severed.

An entirely different envelope of motion was used by the same subjects during natural, functional chewing. The functional envelope of motion was much smaller and well within the borders of the total envelope of motion (Fig. 11). The natural, functional envelope is controlled reflexively, mainly by nerves and muscles.

LATERAL MOVEMENTS

Some dentists believe that lateral movements are completely outside the functional range of motion and that they play no part in occlusion. Although my findings demonstrate that the mandible drops behind the most retruded position when the subject opens the mouth. I cannot entirely agree with the statement that "as he engages in functional closure the mandible moved forward to (but not beyond) that position"[4] (Fig. 12). Some of the records demonstrated that the fields of function and lateral movements (rubbing movements) were not completely divided either before the level of intercuspation was reached or even after it was reached (Figs. 13, 14, and 40). There was evidence of some rubbing together of the teeth during the final phase of natural function (Figs. 15, 22, 25, 28, 32, and 33). The wide range of movement in the horizontal plane (one of the principal movements of articulators) occurred much less frequently than movements over a smaller range (Figs. 20, 22, 24, 25, 27, 28, 33, 34, and 36).

Lateral rubbing movements were also evident from observations of the casts functioning outside of the mouth, both as the food was reduced and in what has been called "the terminal functional orbit."* These movements appeared to be shearing movements. Sometimes they appeared long before the position of intercuspation was reached. Jankelson[5] suggested that these lateral movements of various ranges may result as ". . . a natural phenomenon of the shift in direction as the opening component of the chewing cycle is approached . . . . ." Although no two of these lateral strokes were alike, when the models reached the range of intercuspation, there was evidence of a certain amount of cuspal guidance. The direction of the natural lateral movements was generally medial, while the direction of the movements of an articulator is usually radial.

The angle of approach as the mandible closed in natural, functional chewing often assumed peculiar individual characteristics. Closure took place on a curved line, a straight line, or a combination of both (Figs. 20, 21, 28, 34, and 36).

The path of closure to the position of intercuspation for adults with malocclusion and healthy oral structures is reflex in nature and is attained without cuspal clashing. Therefore, the closure in involuntary chewing seems to be a result of muscular coordination and nerve control. Thus, what appears as cuspal guidance may be nothing more than involuntary neuromuscular coordination in closing.

*Theodore Messerman: Personal communication, March, 1959.

The roll of the head and neck musculature in mastication has been impossible to determine because of the inaccuracies of recording the movements of the head. The head plays an important role in tearing, pulling, and generally assisting with mastication when eating sandwiches, raw fruit, or meat on bones. But this research was concerned only with average size boluses of food, which are generally chewed unilaterally on the preferred side. Large boluses often require bilateral mastication. This still must be investigated.

MOVEMENTS IN THE SAGITTAL PLANE

The opening movement of the mandible in the sagittal plane was usually anterior to the closing stroke, and at maximum opening, the movement of the recording stylus usually terminated in a point when the mouth was empty (Fig. 16). The start and finish as well as the length of the movements were the same in either forced retrusion or the normal maximal opening stroke with the mouth empty.

It was impossible to retrude the mandible forcefully and attain its maximum opening. However, as soon as translation of the condyles occurred and the condyles left the mandibular fossae, maximum opening was achieved.

The closing stroke was in two parts when the extreme envelope of movement was made with the mouth empty (Figs. 17 and 26). The lower part of the envelope of motion represents rotation *and* translation about moving transverse axes. The

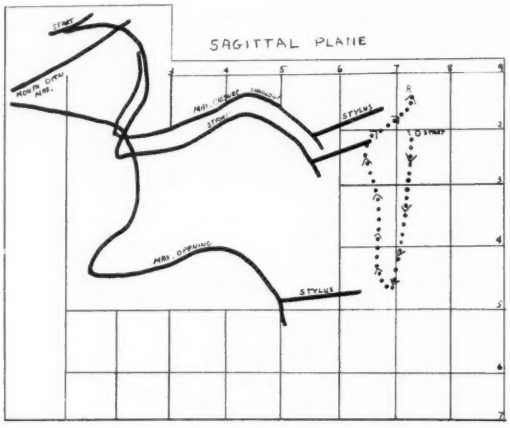


Fig. 19.—The subject is chewing a carrot. The opening stroke is anterior to the closing stroke on the twenty-ninth chewing cycle. The times are 3/16 second at the start, 4/16 second to open, and 8/16 second to close.

upper part of the envelope of motion represents rotation about the transverse axes which lie in or very close to the condyles. This part represents hinge closure.

With the mouth empty, forced retrusions by either the subject or the dentist occurred along the posterior border path and were identical. The natural opening stroke was further anteriorly than the closing stroke with the mouth empty (Fig. 16).

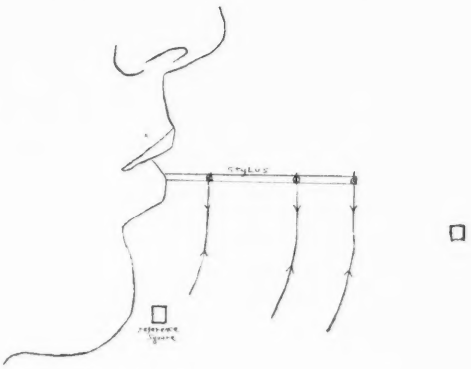


Fig. 20.

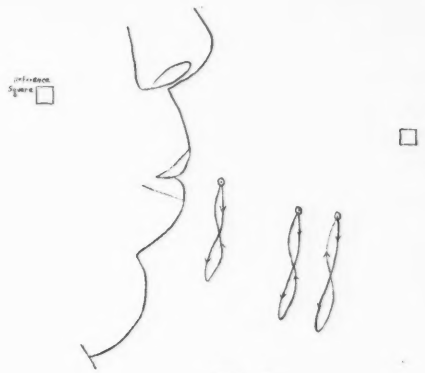


Fig. 21.

Fig. 20.—The subject is chewing a hard crust of bread. Opening and closing occur along the same path on the seventeenth cycle. The times are 7/16 second to open and 6/16 second to close.

Fig. 21.—The subject is chewing a hard crust of bread. The opening and closing strokes cross each other at the halfway mark. The times are 4/16 second for opening and 9/16 second for closing.

The opening stroke when chewing food was usually posterior to the closing stroke at the start (Fig. 18). However, as the chewing progressed, the opening stroke was sometimes anterior (Fig. 19), posterior, along the identical path (Fig. 20), or even crossed over from the closing stroke (Fig. 21). The chewing cycles in the sagittal plane with food in the mouth usually occupied a small area of the extreme envelope of movement.

The length of the functional opening stroke was usually not more than one-half to three-fourths that of maximal opening. The end of the natural opening cycle when chewing food was either pointed (Fig. 25), flat (Fig. 26), curved (Fig. 21), or a combination of these. The rubbing movements with the teeth in contact project out from the top and anterior part of the diagram (Figs. 22 and 28).

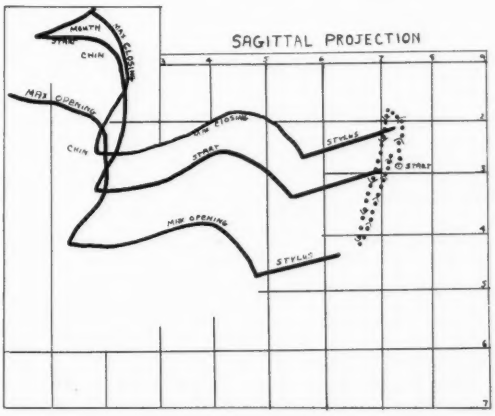
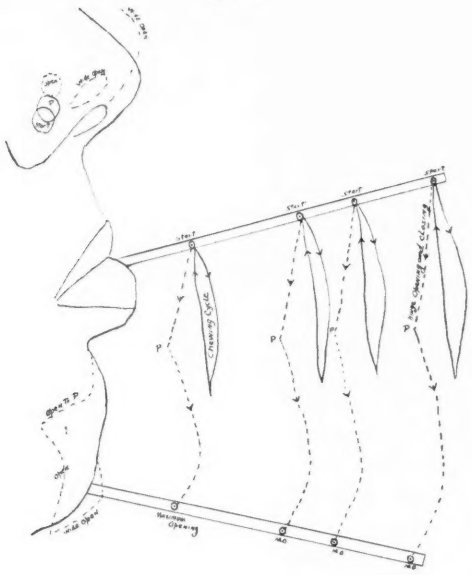


Fig. 22.—The subject is chewing a carrot on the seventh cycle. There is evidence of anteroposterior rubbing at or close to the level of intercuspation. The times are 8/16 second from the start upward, 5/16 second for opening, and 3/16 second for closing.

The posterior borderline or hinge closure which represents rotation about the transverse axis in the condyles did not seem to be reached in functional chewing when viewed in the sagittal plane (Fig. 23). The angle and length of the closing stroke were determined by the type of food, the vertical overlap of the anterior teeth, and the neuromuscular control. The closing stroke did not show this angular line in some vertical chewing strokes (Fig. 25).

Fig. 23.



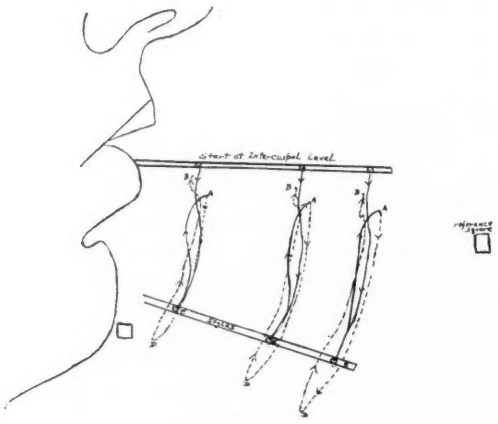


Fig. 24.

Fig. 23.—The dotted line represents the posterior borderline. The chewing cycle does not reach the posterior border or line of hinge closure. The time required is 7/16 second for opening and 6/16 second for closing.

Fig. 24.—The first chewing cycle requires 12/16 second for opening to *E* and 8/16 second for closing to *A*, which is below the level of intercuspation. The second chewing cycle starts at *A*, opening to *D*, and closing to *B*, which is still not at the level of intercuspation.

The beginning of the chewing cycle was below the level of intercuspation when chewing started from the rest position. The individual chewing cycles got smaller and smaller when tough food was broken up and mixed with saliva. At intervals, the tongue, lips, and cheeks gathered the food in small heaps and loaded it upon the occlusal platform. In these instances, the opening stroke was once again large, then got smaller as chewing continued. Often, the individual chewing strokes ended below the level of intercuspation, indicating that some food remained between the teeth (Fig. 24). Finally, the stylus went above the level of intercuspation as deglutition occurred, indicating that the subject's head was thrown back in deglutition.

A great deal of variation existed between the cycles. Some variation was caused by loading of the food by the tongue on the occlusal surface of the teeth. The closing part of the cycle shears and compresses the food and, therefore, is more effective than the opening stroke.

Often, the mandible remained in the area of the start of the masticatory stroke for from 1/5 to 1/3 second before the opening stroke occurred. This pause may be for resting or for applying pressure at the level of intercuspation, or both. The pause occurred too frequently to be accidental.

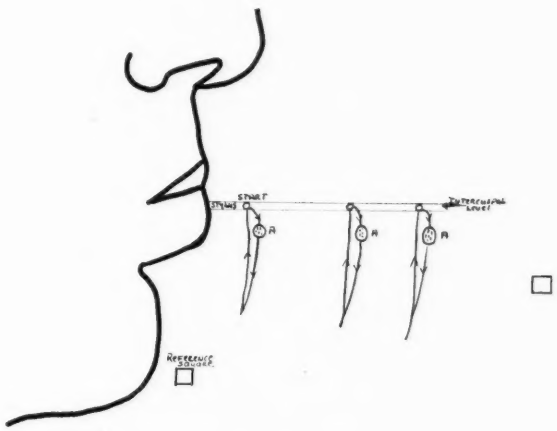
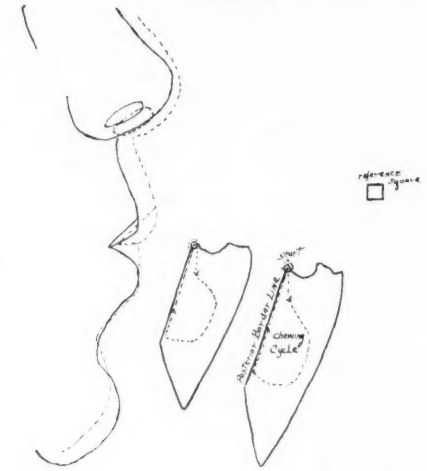


Fig. 25.—The subject is chewing a hard crust of bread. There is evidence of rubbing of the teeth posteroanteriorly at the start in the opening stroke. The closing stroke was straight upward to the level of intercuspation. The times required are 5/16 second to open to *A*, a 6/16 second pause in the area of *A*, 3/16 second to complete the opening, 5/16 second to close to the starting position, and a 5/16 second pause in the area of the starting position.

There were times during both the opening and closing stroke when the mandible stayed in one area for ½ to even 1 second (Fig. 25). The tongue may have been searching the buccal vestibules for some trapped food, or a large bolus may have been difficult to break down. The average single opening or closing cycle with such foods as carrots, bananas, or even meat took from 1/5 to 1/2 second.

In the final phase of chewing, the condyles are braced against the lower posterior border of the articular eminence while the mandible reaches its level of intercuspation.

Fig. 26.



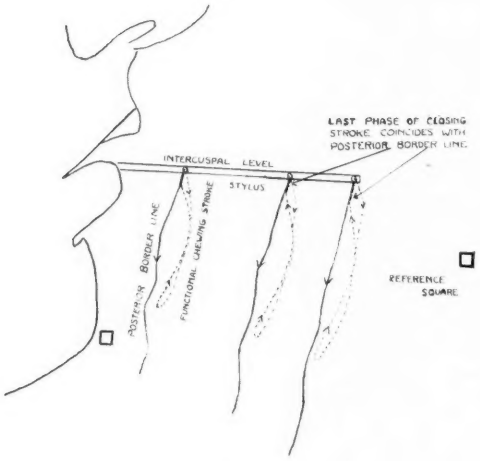


Fig. 27.

Fig. 26.—The total envelope of motion is superimposed on the chewing cycle. The subject is chewing hard candied orange peel. The closing stroke appears to be on the posterior border path. The facial contours are not identical, but the stylus marks are superimposed correctly.

Fig. 27.—The chewing cycle is superimposed on the posterior borderline or the line of farthest retrusion of the mandible. The last part of the closing stroke coincides with the posterior border or hinge line. The subject is chewing a hard crust of bread.

It has been suggested that these photographs were made from the side of the nonworking condyle (which was in translation) rather than the working condyle in its hinge-anchored position and that intercuspal interference may have caused the mandible to be pulled forward in swallowing.* In power closure, both condyles should be in the hinge position when the mandible reaches the level of intercuspa-

*C. A. Brekke: Personal communications, March and December, 1958.

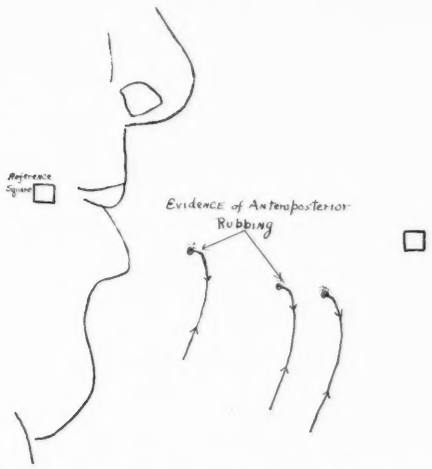


Fig. 28.—The subject is chewing a hard candied orange peel. The closing and opening paths coincide. This is evidence of anteroposterior rubbing of the teeth at the level of intercuspation. The times are 6/16 second in the area of the start, 9/16 second for opening, and 7/16 second for closing.

tion. While the belief in some theories of occlusion is that the mandible follows the posterior border path during power chewing, only infrequently did this occur (Figs. 26 and 27).

Some investigators[6,7] maintain that anteroposterior movements take place in the sagittal plane only when the anterior teeth are used for the prehensile act and that the rubbing movements of the posterior teeth are only laterally and transversely directed when the posterior teeth are in function. However, distinct anteroposterior rubbing movements were observed while watching the casts of a subject chewing natural food. The casts were outside the mouth and attached to the subject's teeth. Some of the sagittal diagrams also confirm these movements, and they were of such magnitude that a misinterpretation of right or left lateral movements on a sagittal projection was impossible (Figs. 22, 25, and 28).

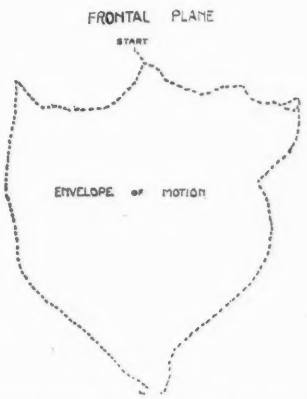
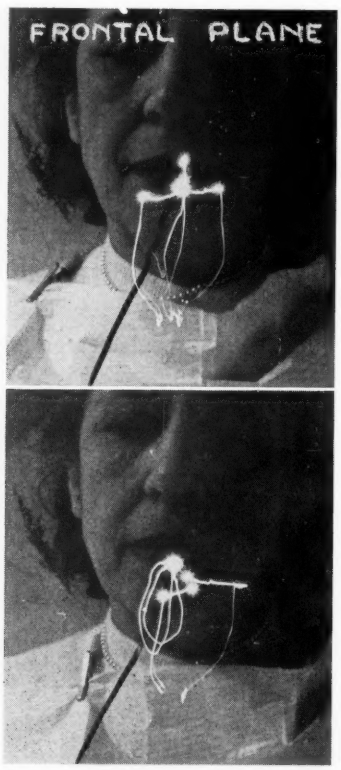


Fig. 29.—The total envelope of motion in the frontal plane.

Fig. 30.—Several functional chewing strokes are included within the total envelope of motion. The subject is chewing a raw carrot. The opening stroke is straight down. The loading is horizontally directed, followed by the closing strokes, which are all on the right side.

A.



B.

Fig. 31.—*A*, The complete envelope of motion is followed by one opening and closing stroke with the mouth empty. *B*, The complete envelope of motion is followed by two functional strokes. The subject is chewing a raw carrot. The head moved slightly, otherwise the functional strokes would be within the total envelope of motion. The strokes in this instance are teardrop in shape.

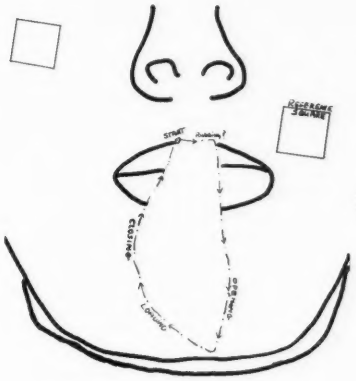


Fig. 32.

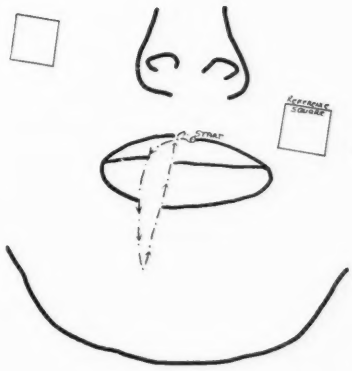


Fig. 33.

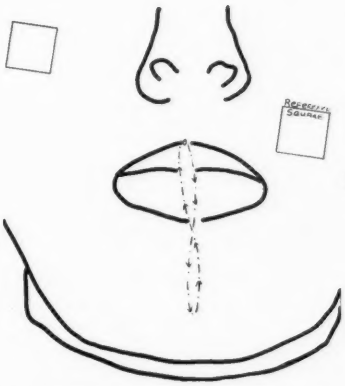


Fig. 34.

Fig. 32.—The subject is chewing a hard crust of bread. There is evidence of rubbing of the teeth at the level of intercuspation during the wide chewing stroke. The times are 4/16 second from the start to the left position, 5/16 second for opening, and a 6/16 second pause in the area of starting.

Fig. 33.—The subject is chewing a hard crust of bread. Note the angulation at the end of the closing stroke. The times are a 4/16 second pause in the area of start, 5/16 second for opening, 3/16 second for closing, and 2/16 second from the top of closing to the starting position.

Fig. 34.—The subject is chewing a hard crust of bread. The opening and closing strokes cross each other about midway in the cycle. The closing stroke is straight upward. The times are an 8/16 second pause in the area of start, 4/16 second for opening, and 4/16 second for closing.

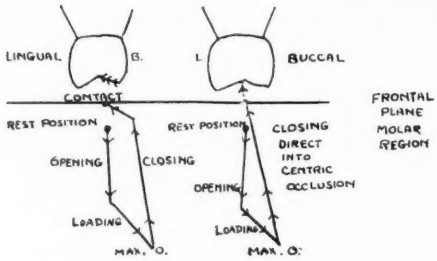


Fig. 35.—The closing stroke in the molar region when chewing soft food was often in a straight line. (From Wild, W.: Functional Prosthetics, Basel, 1950, Benno Schwabe & Co.)

MOVEMENTS IN THE FRONTAL PLANE

In the frontal plane, the extreme envelope of jaw movement with the mouth empty produced a seagull-shaped tracing. The lateral arms of the tracing spread widely to the right and to the left and came to a point at extreme opening (Fig. 29). Wings of the tracing are curved because of the convexities of the cusps. The length of the angulation at the top of the side arms differed with the ability of the subject to make right and left lateral movements. The shape of the total tracing

Fig. 36.

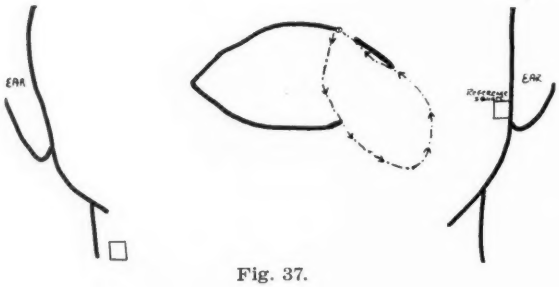


Fig. 37.

Fig. 36.—The subject is chewing a hard crust of bread. From the level of intercuspation, the opening stroke ends at *A*, closes to *B* (which is below the level of intercuspation), then opens again to *C*, and closes to the level of intercuspation. The times are 2/16 second at the start, 7/16 second to open to *A*, 4/16 second to close to *B*, 4/16 second to open from *B* to *C*, and finally 7/16 second to close to the starting position.

Fig. 37.—The subject is chewing a hard crust of bread. The closing stroke is medially directed, which is quite common in reflex functional chewing. The times are 3/16 second at the start, 6/16 second for opening, and 9/16 second for closing.

was similar to that of a shield. These movements depend on the nerves and ligaments, the degree of incisal overlap, the cusp height of the posterior teeth, and to some extent the musculature.

The natural functional envelope during chewing was much smaller and well contained within the extreme envelope (Fig. 30). The opening stroke with the mouth empty was more or less vertical and was usually more rapid than the closing stroke (Fig. 31). In functional chewing, the closing stroke occurred most often from the side on which the chewing was performed. The wide part of the cycle from the end of the opening to the start of the closing stroke is said to represent

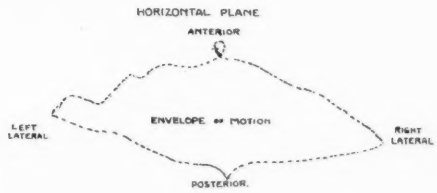


Fig. 38.—The complete envelope of motion in the horizontal plane.

the loading of the food on the occlusal surfaces of the teeth. However, it also may represent a movement of the mandible into a more effective working position, depending on the type and size of the bolus (Fig. 32).

The chewing diagram was occasionally teardrop in form (Fig. 31). Chewing often took place on one side only. As the bolus was reduced, the strokes became smaller and smaller until swallowing occurred. Sometimes, the tongue gathered the food in a small heap, and then the masticatory stroke was large.

During the final crushing of the food and swallowing, the indicator was located in a small area in the neighborhood of centric occlusion but did not remain at one point. During this time the debatable rubbing and crushing between tooth cusps occurred in the terminal functional orbit until final swallowing (Fig. 32). Once again, the final part of the closing line was often angulated (Fig. 33).

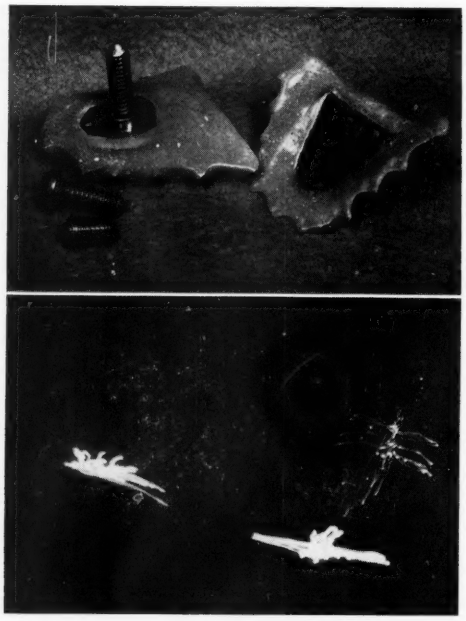
The degree of angulation and the size of the final closing line depend upon the angulation of the buccal and lingual cusps of the upper and lower posterior teeth as they intercuspate in lateral movements in the terminal functional orbit. Neuromuscular coordination may also be a factor. The masticatory strokes in the frontal plane, which are predominantly vertical, do not have this angulated terminal end of the closing stroke (Fig. 34).

The neuromuscular system may be responsible, in part, for the steepness of the angle of closure during mastication. The form of the diagram in the frontal plane depends upon the toughness of the food and the areas of posterior tooth contact. With fibrous food which is difficult to chew, the closure may be erratic until the lower teeth reach the upper buccal working surfaces. Then the lower cusps slide into centric occlusion. This is the phase of rubbing which is in a transverse or lateral direction toward the midsagittal plane. With soft food, the closing stroke was often directly in a straight line from the side of chewing into centric occlusion

at the level of intercuspation (Fig. 35). Once again, mastication may start below the level of intercuspation at rest position. However, the teeth did not always reach the level of intercuspation, as with hard foods during the reducing period (Fig. 36). Here again, the masticatory strokes were similar but not duplicates of each other. Sometimes, the paths were crossed over from right to left when the tongue placed the bolus on the opposite side (Fig. 34). Many of the movements were made from the lingual (medial position) to the buccal (lateral position) in voluntary chewing. Reflex functional chewing was generally directed medially (Figs. 32 and 37).

Deglutition occurred several times during the chewing of a bolus. Saliva was being constantly mixed with the food. The tongue, lips, and cheeks were always at work keeping the food on the occlusal surfaces of the teeth. The chewing was both

A.



B.

Fig. 39.—*A*, The intraoral tracer enables the dentist to change the vertical relation to three or more levels and make tracings at each level. *B*, Horizontal, frontal, and sagittal tracings are made with an intraoral tracer in position at three different levels of opening, including the level of intercuspation. First, rubbing movements of the teeth are made, then one opening and closing movement. The most important level is that of intercuspation.

cyclic and angular. In final swallowing, the head moved back, and a curved line was seen above the centric contact area in the diagram.

THE HORIZONTAL PLANE

In the horizontal plane, the extreme envelope of movement made with the teeth in contact looked somewhat like a diamond or two seagull-shaped tracings

with their apices pointed opposite each other (Fig. 38). The opening stroke was somewhat like a straight or curved line projecting out from the apex of the most posterior seagull tracing. The opening movement curved toward the rear and, in this perspective, looked like a line behind the seagull tracing (Fig. 8). This line in a sagittal projection represents the posterior border path (Fig. 9).

The functional chewing envelope of movement may appear to one side and behind the seagull tracing or on both sides (Figs. 12 and 13). The envelope may cross over the posterior terminals of the seagull tracing and appear within the diamond-shaped area (Figs. 11 and 13), representing the rubbing and tearing of food in or near the terminal functional orbit. The envelope may also represent the translating condyle in any open position of the mandible.

In final swallowing, the indicator was sometimes found at the apex of the seagull tracing but more often slightly anterior to it. The subject's head moved back

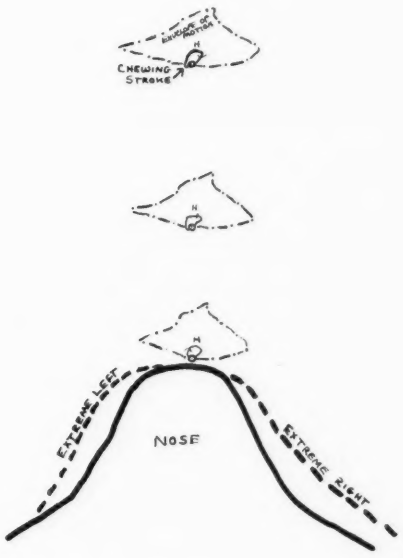


Fig. 40.—The subject is chewing a hard crust of bread. The chewing stroke appears to be within the envelope of motion in this projection.

at final swallowing, and once again a line above and anterior to the apex of the seagull tracing was seen in the diagram. The diamond formed by the extreme envelope of movement was narrow between the apices and wide laterally (Figs. 10 and 38).

The areas of function and nonfunction may be considered in the horizontal plane. While it is true that there is a definite centric relation for each level of vertical opening (Fig. 39), function and nonfunction can be described only at one specific level. This level is the level of intercuspation or the level at which all chewing terminates.*

*C. A. Brekke: Personal communications, March and December, 1958.

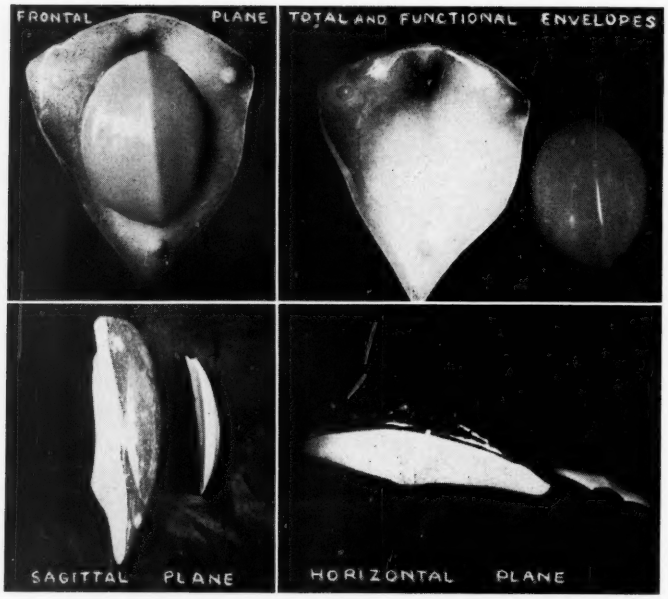


Fig. 41.—Models of the envelopes of motion. Both the total and functional envelopes of motion are shown for comparison of size and position.

Most functional chewing occurs in the sagittal plane. However, some functional chewing also takes place in the horizontal plane and at the level of intercuspation. Some subjects chew anteroposteriorly and posteroanteriorly from the retruded position of the mandible to a forward position within the confines of the seagull tracing, at or very close to the intercuspal level, in the horizontal plane (Figs. 14 and 40).

Even though I may have recorded the action of the translating condyle, which is the nonworking member, both condyles work even though one may work less effectively at any given moment. Many subjects chew on both sides simultaneously, especially when chewing large boluses of food.

The terminal chewing stroke is in the region of the apex of the seagull tracing. Chewing on the horizontal plane is usually done on the preferred side and generally in a buccolingual direction. The subject makes many eccentric movements which may be due to individual nerve impulses.

THE ENVELOPES OF MANDIBULAR MOVEMENT

I have made a model based on the diagrams from 1 subject used in this research to give a composite picture of the total envelope of motion and the functional envelope. It demonstrates the difference between these two envelopes (Fig. 41).

CONCLUSIONS

Our true capacity to advance in dental science depends upon the depth of our understanding of the fundamentals which underlie our knowledge of biologic and

dental facts. In spite of the remarkable progress, our understanding of fundamentals is woefully inadequate. While we can perform near miracles in prosthodontics and even can improve upon the natural conditions, we are unable to answer many of the simplest questions raised from scientific observation in the dental sciences. An enormous reorientation of our scientific effort into long range, undirected basic research is needed to fill in the glaring gaps in our knowledge.

Research that is carried out with patience and persistence will bring new life to dentistry. By means of research, science is advanced, knowledge is increased, and humans win an even greater freedom from dental disease.

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CHARACTERIZED IMMEDIATE DENTURES

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Ramstein Air Base, Germany

INCREASING PATIENT DEMAND for characterized immediate dentures places the dentist in a position where he must be both proficient in a technique and familiar with the newer materials used in fabricating the desired prostheses.

This article is intended to give a practical and logical sequence of step by step procedures to duplicate or simulate, with complete immediate dentures, the patient's natural dentition and supporting structures.

PATIENT HISTORY

A complete and accurate patient history is of the utmost importance. The time required to accomplish this is well rewarded by the impression on the part of the patient of the dentist's thoroughness and personal interest. More important is the information that will be revealed for determining the desirability of immediate dentures, the problems anticipated, the psychologic handling of the patient, and the result expected. Charts for recording this information are available in textbooks or can be designed by the dentist to suit his individual requirements.

DIAGNOSTIC CASTS

Accurate, mounted diagnostic casts made from hydrocolloid impressions are necessary to determine the course and scope of treatment. These casts serve also for the fabrication of trays for making the final impressions and as a permanent record of the natural teeth in the final setup.

The posterior teeth are extracted and the ridges contoured, and 10 to 14 days is allowed for healing.

FINAL IMPRESSIONS

Self-curing acrylic resin impression trays are underextended approximately 2 mm. around the entire denture border and terminated 2 mm. short of the gingival margins lingual to the six anterior teeth. The buccal flanges are extended to the distal surface of the cuspids. The impression is border molded in sections. Green stick modeling plastic is added to each area, flamed with an alcohol torch, tempered in water at 135° F., and seated in the mouth; the tissue shape and position for that region are recorded. The modeling plastic is chilled with water from a syringe,

*The opinions or assertions contained herein are those of the author and are not to be construed as official or as reflecting the view of the Department of the Air Force or the air service at large.

removed from the mouth, immersed in ice water, reduced buccolingually with a razor sharp knife to a width of 2 to 3 mm., and rechecked in the mouth. There should be no dislodgement of the tray when the tissues are manipulated. Should there be underextension or overextension, the same procedure is repeated until a well-defined border is established with no dislodgement of the impression tray. Each segment of the border must be perfectly fashioned before proceeding with the next section. Patients with excessive saliva are given premedication of 50 mg. of methantheline bromide 30 minutes before the impressions are made.

Maxillary Final Impression.—The following procedures are used to establish the form of the borders of the impression. The tray is stabilized with the right index finger in the center of the palate to equalize pressure while border molding the left side. These positions are reversed for the right side.

Left buccal flange: The dentist stands behind the patient. With the fingers of the left hand placed inside the patient's cheek and the thumb outside, he pulls downward, forward, and inward, allowing sufficient time for the modeling plastic to flow.

Right buccal flange: The hands are reversed and the same procedure is followed.

Left buccal frenum: The cheek is grasped with the left index finger inside and the thumb outside. By pulling downward, then forward and backward, space is provided for the buccal frenum.

Right buccal frenum: The hands are reversed and the same procedure is followed.

Posterior border extension: An indelible pencil line is drawn across the vibrating line and transferred to the tray. Green stick modeling plastic is added across this area. After the tray has been seated, the patient's nostrils are occluded by pressure of the dentist's left thumb and index finger, and the patient is instructed to attempt to blow his nose.

Petroleum jelly is applied to the patient's face, the mouth is rinsed with water, and the mucous membrane is dried with a surgical sponge. A rubber-base impression is made of this area. Numerous holes are drilled in the acrylic resin tray with a No. 4 round bur. The tray is painted with adhesive and allowed to dry, and the rubber-base impression material is applied and gently seated with a vibratory motion. The patient makes all possible muscular movements to mold the denture border. After setting, the impression is removed and inspected, and the excess that has extruded into the lingual interproximal spaces between the anterior teeth is removed with a sharp scissors. A rim lock tray of a size ample to cover the posterior impression and natural teeth is selected. The tray is provided with a large hole in the palate and filled with alginate (irreversible hydrocolloid) impression material. The posterior impression is seated in the mouth, and the rim lock tray is vibrated into position with the index finger extending through the hole to stabilize the posterior impression previously made. The patient makes muscular movements to border mold the region of the anterior dental arch. After setting, the impression is removed and the excess alginate is removed from the buccal frenum and buccal flange regions. The border height of the anterior arch region is reduced 2 mm. with a sharp knife perpendicular to the labial surface. This

method, although arbitrary, eliminates postoperative adjustments in this region with no apparent untoward effects on retention or stability. The patient is also afforded greater freedom of facial expression.

Mandibular Final Impression.—The tray is stabilized with the index and middle fingers on the top of each side of the tray, while the thumb is under the patient's chin. The borders are molded sectionally as in the maxillary impression technique.

Left buccal flange: The dentist stands in front of the patient. The left hand supports the tray while the right thumb is placed inside the patient's cheek, the fingers outside. He pulls the cheek upward, forward, and inward.

Right buccal flange: The hands are reversed and the same procedure is followed.

Left buccal frenum: The cheek is grasped with the right thumb inside and the index finger outside. The dentist pulls upward, then forward and backward to clear the buccal frenum attachment.

Right buccal frenum: The hands are reversed and the same procedure is followed.

Left lingual flange: Green stick modeling plastic is applied to the tissue side of the tray and seated in the mouth. The patient then makes maximum tongue movements, first anteriorly, then to the right corner of the mouth, and last to the left corner of the mouth (note that the tongue is first extended to the side opposite that being molded). The excess modeling plastic is removed, allowing the border roll to remain. This takes advantage of the lingual undercuts while still obtaining a functional border roll

Right lingual flange: The hands are reversed and the same procedure is followed.

Left mylohyoid, right mylohyoid, and sublingual borders: The borders are all established with the same tongue movements.

Exaggerated tongue movements more nearly prevent denture dislodgement and still maintain maximal retention and limit postoperative adjustments. Rubber-base impression material is used in a manner similar to that for the maxillary impression. A rim lock tray with large holes cut over each first molar area is filled with an irreversible hydrocolloid impression material. The middle and index fingers are inserted through the holes to stabilize the posterior impression while the patient makes muscular movements of the face. After setting, the impression is removed and the excess impression material is trimmed from the buccal borders of the impression. The height of the labial flange is reduced 2 mm. as for the maxillary impression. The impressions are poured immediately in artificial stone.

JAW RELATION RECORDS

Baseplates covering the edentulous areas are constructed. Tinfoil (0.003 inch) is burnished over the casts, allowing a wide apron. Zinc oxide–eugenol paste is placed on the impression side of the baseplate. The baseplate is seated in position, and, after setting, the excess zinc oxide–eugenol material is trimmed away. This provides a well-adapted, stabilized baseplate. Posterior occlusion rims of

pink baseplate wax are constructed to approximate the form of the tissues that originally occupied the available space anteroposteriorly and buccolingually.[1]

A tentative occlusal plane is established corresponding to the tragus-ala line, and the mandibular occlusion rim is reduced to allow 2 to 3 mm. of clearance between the upper and lower occlusion rims. Wax* is softened in a Bunsen flame, placed on the mandibular rim, and puddled with a No. 7 wax spatula. The patient is directed to bring the occlusion rims gently together with minimal pressure in a tentative centric relation. The position of the condyles is marked arbitrarily 11 mm. anterior to the meatus of the ear.[2] If desired, the kinematic axis of rotation may be determined with a hinge axis locator. The casts are placed in the occlusion rims, and a face-bow fork, with its prongs removed, is heated and centered in the wax. This prevents distortion of the baseplates and interference from the natural teeth when the occlusion rims are replaced in the mouth. The condylar rods are adjusted in contact with the tissues with equal readings on the two sides. This centers the face-bow, and then it is locked and removed.

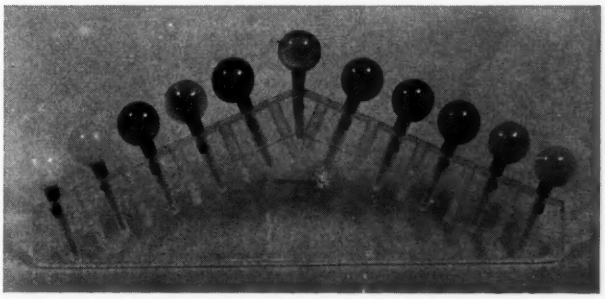

Fig. 1.—The tissue shade guide: *(W)* white (Lucitone gingival tone); *(P)* light pink (Coloform, hue 2); *(C)* clear with fibers (clear Acrylite plus Kayon red nylon fibers); *(Y)* yellow; *(N)* brown; *(B)* blue; *(E)* purple; *(R)* red; *(A)* light red; *(F)* medium red; *(H)* pink (the latter all Kayon stains).

CHARTING OF TISSUES

I have found the use of a tissue shade guide (Fig. 1) and a tissue tinting chart (Fig. 2) indispensable in duplicating the patient's natural teeth and tissue colors. Frush and Fisher[3] stated, "The environment of the tooth is as important as the tooth itself."

A tissue shade guide composed of ten shades of denture stains is easily made. Buttons 15 mm. in diameter are made from wax patterns melted into the bottom of a dappen dish. They are flasked, boiled out, and covered with tinfoil, and each color is cured at 165° F. for 9 hours. The teeth are removed from any shade guide and replaced with processed, polished buttons of denture-base material which are attached by autopolymer resin of the same shade and numbered (Fig. 1). All peculiarities of the patient's teeth which are to be duplicated are marked on the chart. The various tissue colors are matched with the shade guide, and the

*Aluwax.

respective areas of the tissue tinting chart are numbered with the corresponding shades. The texture of the natural tissue is noted. I match and record the color of the gingivae first, then the basic color, the upper third of the flange area, the root prominences, and finally any other unusual tissue colors (Fig. 3). With a little practice, this is done easily, quickly, and effectively. The chart may be used by the dentist who does his own staining, or it may be utilized by a trained laboratory technician. I have found the basic principles of the Pound technique[4] to most adequately meet my requirements. (See "Laboratory Procedures.")

(NAME) Sample Case (DATE)
E+F
E+F
F
F
INCISAL ATTRITION
E+F
E+F
.6 – ¾ gold crown, yellow erosion, black spots
.7 – Facing #50 OP
.8 – ¾ gold crown, yellow erosion, yellow dil
.9 – Facing #50 OP
.10 – Yellow brown erosion, white fracture lines
.11 – Brown dil, white fracture line
.12 – Black decay, horizontal brown fracture
.13 – White fracture lines
.16 – White fracture lines
.17 – White fracture lines, dark brown erosion

Fig. 2.—A tissue tinting chart.

PRELIMINARY SETUP

By means of a face-bow transfer, the casts are mounted on an articulator.* The maxillary cast is attached with Hydrocal, the mandibular one with plaster of Paris.

The bicuspids and molars are set up in centric occlusion on the stabilized baseplates. No attempt is made to establish occlusal harmony in eccentric mandibular movements at this time.

TRY-IN

The palate is dried with a surgical sponge. An indelible pencil is moistened, and a fine line is drawn across the posterior border of the baseplate, which is in-

*Hanau model H.

serted into the mouth; the patient is instructed to attempt to blow through the nose while the nostrils are occluded. A sharp, thin indelible line is transferred to the oral mucosa, and any overextension of the baseplate is reduced with a trimmer.* The same procedure is repeated until the exact extension to the flexure line of the palate is established. The maxillary wax setup is replaced on the cast, and the finish line is scribed on it. The posterior palatal seal is cut into the cast as determined by clinical observation and the type of seal indicated.

The mandibular cast is removed routinely from the lower member of the articulator. Double thickness wax† is softened, placed on the occlusal surfaces of the posterior teeth, and puddled to a uniformly soft consistency, and the patient's jaw is closed in centric relation, avoiding tooth contact. The casts are oriented with this interocclusal record, and the lower cast is remounted on the articulator with Hydrocal. The protrusive interocclusal record is made in a similar manner, after first having the patient practice bringing the natural anterior teeth in an edge to edge relationship. The condylar guidances are set, and the incisal guidance is adjusted to relations of the patient's natural teeth. Lateral condylar guidances are set according to the formula on the instrument. New interocclusal wax records are made on the articulator and rechecked in the patient's mouth. If these do not coincide, the entire procedure is repeated until they do coincide exactly.

LABORATORY PROCEDURES

The posterior teeth are reset into balanced occlusion. The gingival crevice of the remaining teeth is marked on the cast with a fine pencil line. This is left untouched as the teeth are removed and replaced one at a time.[5] Each tooth, before being replaced, is sculptured with the preliminary cast as a guide and characterized,[6] according to the chart. A labial socket 2 mm. deep is cut into the cast with a No. 2 round bur forming a trench inside the pencil line. Alternate teeth are waxed into position until the setup is complete. Twenty-eight gauge green casting wax is burnished on the intact labial flange area with a toothbrush handle, and the gingival margin is trimmed to the pencil line with a sharp knife. Eight gauge, half round inlay wax (12 gauge in the mandibular wax-up) is luted to the border of the wax pattern of the denture base in the anterior region. The rounded side is placed outward to avoid an undesirable knife edge flange. Wax melted on a No. 31 spatula may be blown on the wax-up to simulate a coarse tissue texture. A fine grain surface is created by stippling with a stiff brush. The posterior part of the denture base is contoured, and all gingival crevices are simulated with a sharp explorer as suggested by Kemnitzer.[7]

The palatal tissues are reproduced with the hydrocolloid-resin technique developed by Walker and Orsinger.[8] Hydrocolloid impressions of the diagnostic casts are made, then sprayed by means of an atomizer with a mixture of 70 c.c. acrylic resin monomer, 15 c.c. wintergreen oil, 15 c.c. camphor crystals, and colored with a pinch of Sudan red dye; 200 mesh ethyl methacrylate powder is dusted on. This process is repeated (three to five times) until the desired thick-

*Arbor.
†Tenex.

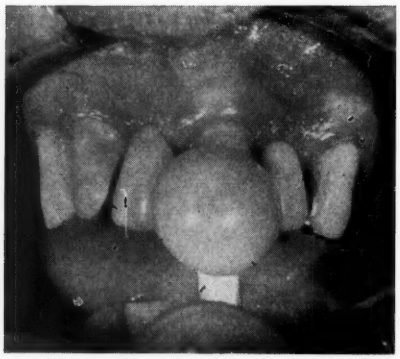

Fig. 3.—Matching a patient's oral tissue colors with a button from the tissue shade guide.

ness is obtained. The pattern is trimmed with scissors, sealed, and waxed on the cast. The land of the flask should slope from the waxed denture border to eliminate a flash on the stained flange areas. After boiling out, the ridge contour of the cast is reduced and contoured with the trimmer, and a clear acrylic resin surgical template is fabricated from an impression of the prepared cast.

With the tissue tinting chart as a guide, the denture base is colored a quadrant at a time for each individual stained area.[10] The powder is sprinkled in and wetted down with monomer applied with a camel's hair brush. The colors are added by area in the following order: (1) clear, (2) vascularity (fibers), (3) gingival tone, (4) root eminences, (5) other areas presenting unusual colors, (6) interdental papillae, (7) basic color (gingival two-thirds), (8) upper third, (9) rugae, (10) anterior two-thirds of palate, and (11) posterior one-third of palate. Acrylic resin monomer is added four times at 5 minute intervals after completing the staining. The denture-base material may be modified to blend with the basic colors by mixing the regular pink polymer in 6:1 ratio with stain two shades darker than the basic color. Underpacking of the flask and the judicious addition of small

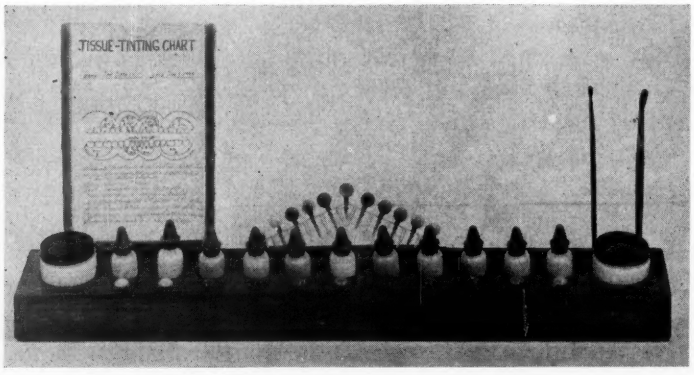

Fig. 4.—The staining stand. All stains, the brushes, the monomer, and the tissue tinting chart are readily accessible, and the tinting chart is in clear view.

amounts of acrylic resin dough in repeated trial packing eliminates distortion and "bleeding" of the stained areas. Cold-curing monomer must be used with the stains in curing with the injection method. The staining stand (Fig. 4) facilitates the staining procedures.

After curing and deflasking, the flash is removed, and the denture borders are polished in the usual manner. Equal parts of utility and baseplate wax are melted together in a metal container and used with a No. 812 wheel brush to polish the stained surfaces in small circular movements. Additional stippling, as in the Frush and Fisher method,[9] may be effected with a No. ½ eccentric round bur with the shank bent at a 5 degree angle (Fig. 5). Light circular movements are used. The denture is brushed with soap and warm water.

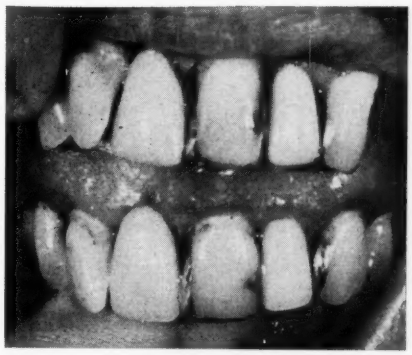

Fig. 5.—A completed denture is placed below the natural teeth to show the accuracy of reproduction.

INSERTION OF DENTURES

The remaining natural teeth are removed and an alveolectomy is performed, using the surgical template as a guide. The dentures are then inserted, any gross occlusal errors are eliminated, and the patient is instructed to return in 24 hours. After 7 to 10 days, centric and protrusive interocclusal records are made, the dentures are remounted on the articulator, the occlusion is refined by selective grinding and milled in with carborundum paste, and the tooth surfaces are polished.

RELINING

Ridge resorption has not proved to be extensive with this technique. The resinous wax impression materials are excellent for functional closed-mouth impressions. The denture borders are reduced, undercuts are removed, the impression material is brushed on, and closed-mouth functional impressions are made. These are flasked and processed with routine laboratory methods.

In any denture service, periodic checkups are mandatory, but they are particularly important in immediate dentures.

SUMMARY

1. A technique for constructing immediate dentures has been described.

2. There must be a balance between biomechanics and esthetics for patient satisfaction and denture success.

3. The restoration of arch form and ridge relationship is of prime importance in maintaining facial contour and expression. Less attempt to improve natural characteristics and greater effort to duplicate remaining structures result in natural-appearing teeth—not beautiful, artificial dentures.

4. Dentists or laboratory technicians with reasonable practice and skill can color the denture base in 15 minutes.

5. Dentists will be compelled to meet the increasing demands of patients for natural-appearing dentures.[11]

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APO 12
New York, N. Y.

USE OF A LAYERED SILICONE RUBBER MOLD TECHNIQUE FOR DENTURE PROCESSING

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THE ADVENT OF SILICONE RUBBER that can be vulcanized at room temperature has made possible a technique of processing dentures in a flexible mold. This may be a significant step forward in the search for improved methods in dental laboratory technology. The investigators had observed the excellence of silicone rubber vulcanizable at room temperature as a mold material in making demonstration and teaching models of acrylic resin. The acrylic resin surfaces produced by these molds required very little polishing, and contours were reproduced in great detail. It was felt that if dentures could be processed against a surface of silicone rubber, with a resulting occlusal accuracy equal to that obtained by conventional means, there would be many advantages to the new procedure. Preliminary laboratory experiments with technique dentures indicated that the occlusal accuracy obtained using a silicone rubber mold might not only be as good as but even significantly better than that generally obtained by processing in a gypsum mold.

A study was undertaken to determine the practicability of fabricating dentures for patients by use of a combination silicone rubber–gypsum mold and to evaluate the occlusal accuracy obtained, compared with that of an all-gypsum mold.

EXPERIMENTAL METHODS

A comparative study was made in which 106 dentures were processed with silicone rubber as an investing agent in the matrix half (cope) of the mold and plaster of Paris in the cast half (drag) of the mold. A control group of fifty dentures was processed using plaster of Paris as the investing agent in both halves of the mold. Some of the dentures in the control group were test packed, since this is generally done when processing in a gypsum mold. None of the dentures in the experimental group were test packed.

Vertical Opening.—After the trial dentures were attached to the casts with wax and the waxing of the dentures was completed, the teeth were placed in occlusion. The incisal guide pin was adjusted to touch the incisal guide table and was locked in position. A measurement in millimeters and tenths of millimeters

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Presented before the American Denture Society and the American Academy of Crown and Bridge Prosthodontics in Chicago and before the Academy of Denture Prosthetics in Minneapolis.
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was made of the pin from its tip to the top of the upper member of the articulator. The casts and trial dentures had been mounted by a split cast method so they could be remounted in their original positions after the dentures were processed. The casts were detached from the articulator, flasked, and processed. After recovery of the dentures from the flask, they were remounted on the original records. The teeth were placed in occlusion, the incisal pin was again adjusted to touch the table and measured as before, and the measurement was recorded.

All 156 dentures were in sets of complete upper and lower dentures constructed for 78 patients. Thus, any change in vertical occlusal opening occurring between the wax-up stage and completion of the dentures was the sum of that which occurred in the processing of two dentures for the same patient, as measured at the incisal pin of the articulator.

Other Occlusal Changes.—Prior to investment of the trial dentures, an occluso-incisal positional index was made separately for each denture by positioning the occluding edges of the teeth into a freshly mixed mass of stone. Positional occlusal changes other than vertical opening were tested by placing the processed denture back on this index. For the first twenty dentures, the index was made while the trial denture was still mounted on the articulator, so that the index would be mounted on the opposite member of the instrument and would record group movement of the teeth in a lateral or anteroposterior direction, as well as the movements of individual teeth in relation to each other. Since group movement of the teeth did not occur in any of the first twenty dentures, the remaining indices, except for spot checks, were made after the casts were split off the mounting records prior to investing.

Types of Matrix Used.—The first sixty-eight dentures were processed in a mold in which the entire matrix side of the mold (upper half of flask) consisted of silicone rubber vulcanizable at room temperature. These are referred to as the all-silicone matrix group of Table I. The occlusal reproduction, in respect to lateral movements, was uniformly accurate in these cases, but changes in vertical opening were less in those dentures which had been flasked with the occlusal and incisal edges of the denture teeth in close proximity to the rigid metal flask cover (within 3 to 5 mm.). This finding suggested the advisability of using a layered mold of silicone rubber backed up by stone. This layered mold proved to have excellent working qualities from a materials standpoint, so the last thirty-eight dentures of the experimental group were processed in a layered mold. These are referred to as the layered silicone matrix group in Table I.

LABORATORY TECHNIQUE

The Layered Mold.—The stone casts carrying the trial dentures were embedded in the lower half of a denture flask in plaster of Paris in the conventional manner, except that no separator was required on the plaster after it had set.

Approximately 30 Gm. of room temperature–vulcanizing silicone* was mixed for each denture to be flasked. If the silicone rubber had been stored in a refrigerator, it was allowed to reach room temperature before mixing. The rate of curing

*Silastic RTV 502.

of the silicone rubber may be modified by varying the amount of catalyst. A ½ hour cure, which included a 10 minute working period, was obtained by adding 0.5 per cent catalyst (approximately three to four drops per 30 Gm.) to the silicone rubber and spatulating for 30 seconds.

The mixed silicone rubber was applied with a wide, flexible spatula over the teeth, wax, and land surface in the flask. Care was taken to make certain that air was not trapped around the teeth. Although the thickness of the silicone layer was not critical, 1 to 2 mm. was considered ideal.

The upper half of the flask was placed in position, and the flask was then completely filled with a mix of artificial stone, poured immediately over the *uncured* silicone rubber. The flask cover was pressed into place.

After ½ hour, when the silicone rubber had cured and the stone had set, the flask was immersed in boiling water for 5 minutes. It was then opened, and the wax was flushed out with boiling water and detergent.

Using a ¼ inch round vulcanite bur, waste gates were cut into the land surface from the labial and buccal borders of the upper and lower casts and from the lingual border of the lower cast, to the edges of the flasks.

A tinfoil substitute was applied to each cast and its adjacent land surface, and the mold was ready for packing. No tinfoil substitute was required on the half of the flask which held the teeth, since this had a surface layer of silicone rubber.

Self-curing denture resin was mixed in a sufficient quantity to slightly overfill the flask, after which the resin was poured into the matrix of the upper half of the flask. The two halves of the flask were then brought together and closed almost completely in a flask press. The excess resin, squeezing out between the two halves, was wiped off. The flask was then closed completely, after which it was held in the press under pressure for at least 2 hours.

TABLE I. CHANGES IN VERTICAL OPENING RESULTING FROM PROCESSING

TYPE OF MOLD	NUMBER OF SETS OF COMPLETE DENTURES*	OPENING AT INCISAL PIN (MM.)		RANGE (MM.)
		MEAN	MODE	
Layered silicone matrix†	19	0.136	0.0	0.0–0.5
All-silicone matrix‡	34	0.561	0.0	0.0–1.8
Gypsum matrix (contro's)	25	0.672	0.7	0.2–1.2
Test pack controls (14)		0.650		0.2–1.0
No test pack controls (11)		0.700		0.1–1.2
Total	78			

*The changes, if any, in vertical occlusal opening occurring between the wax-up stage and the completed dentures is the sum of that which occurred in the processing of two dentures for the same patient as measured at the incisal pin of the articulator.

†The upper half of the mold, which holds the teeth and forms the matrix for the polished surfaces of the denture, consisted of a layer of silicone rubber vulcanizable at room temperature backed by sufficient dental stone to fill the flask.

‡The upper half of the mold, which holds the teeth and forms the matrix for the polished surfaces of the denture, consisted entirely of silicone rubber vulcanizable at room temperature.

The denture was recovered by gently prying open the two halves of the flask, at which time the silicone rubber mold easily slipped off the cured denture, leaving an unusually smooth and clean surface on the resin and the teeth since no plaster had been in contact with either.

RESULTS

Changes in vertical occlusal opening (measured at the incisal guide pin) occurring between the wax-up stage and the completion of the dentures are shown in Table I. The layered silicone mold technique gave the most consistent results and was as well an average of four to five times more accurate than the all-silicone or all-gypsum matrix in reproducing the correct vertical dimension.

Table II lists the occlusal opening values obtained for each set of dentures processed by the layered silicone rubber mold method. The mode figure, i.e., that which occurred most often, was 0.0 mm.; the mean was 0.136 mm. Fifteen sets (78.5 per cent of the sets of dentures) had vertical openings of 0.2 mm. or less. The largest vertical opening recorded in the layered silicone rubber mold series was 0.5 mm., and there was only one instance of this.

TABLE II. CHANGES IN VERTICAL OPENING RESULTING FROM PROCESSING IN THE LAYERED SILICONE RUBBER MOLD*

CASE NO.	PIN OPENING (MM.)	CASE NO.	PIN OPENING (MM.)
38	0.5	51	0.3
41	0.1	53	0.0
42	0.0	54	0.0
43	0.2	55	0.0
44	0.2	56	0.2
45	0.0	57	0.2
47	0.1	58	0.0
48	0.2	66	0.3
49	0.1	81	0.1
50	0.1		

*The upper half of the mold, which holds the teeth and forms the matrix for the polished surfaces of the denture, consisted of a layer of silicone rubber vulcanizable at room temperature backed by sufficient dental stone to fill the flask.

Table III lists the occlusal opening values obtained for the controls. The mode figure for the controls was 0.7 mm., the mean 0.672 mm. Seventeen sets (68 per cent of these sets of dentures) had a vertical opening of 0.6 mm. or more. The largest vertical opening recorded in the control group was 1.2 mm., which occurred twice. The smallest opening recorded was 0.1 mm., and there was only one instance.

Statistically, there was no significant difference in the results obtained by test packing or not test packing in the control group. There was a highly significant difference, however, between the controls and the experimental group ($t = 9.067$, using Fisher's test of statistical significance for small samples).

Minor tooth movements seen fell into no characteristic pattern of difference between the experimental and control groups. In both groups, movement was seen

TABLE III. ALL-GYPSUM MOLD*; CONTROLS

CASE NO.	PIN OPENING (MM.)	CASE NO.	PIN OPENING (MM.)
36	1.0	69†	0.4
37	1.2	70†	1.0
39	1.2	71†	0.9
40	0.7	72†	0.3
46	0.4	73	0.4
52	0.7	74†	0.7
59	0.7	75†	0.7
62	0.7	76	0.1
63†	0.9	77†	0.4
64†	0.4	78†	0.6
65†	0.2	79†	0.6
67†	1.0	80	0.6
68†	1.0		

*The upper half of the mold, which holds the teeth and forms the matrix for the polished surfaces of the denture, consisted entirely of plaster of Paris.
†Test packed.

only in a vertical direction. All tooth movement in both groups was well within the range of adjustment by selective grinding after the processed dentures were remounted on the original mounting records of the articulator.

DISCUSSION

The investigation conducted shows that a layered silicone rubber mold produces more accuracy of occlusal reproduction in a denture than that obtained with the conventional gypsum mold. This is a clinically significant finding. However, some of the other additional advantages of a flexible silicone rubber mold surface may ultimately be more important.

Fabrication of Duplicate Dentures.—The silicone rubber portion of the mold, which holds the denture teeth and provides the matrix for the polished surfaces of the denture, is not destroyed or injured during processing. This provides a means for the routine fabrication of a duplicate or spare set of identically appearing dentures, if desired. The technique is relatively simple from a laboratory standpoint and does not require any additional time or procedure at the chair for either the patient or the dentist. All that are required are (1) an extra flask the lower half of which fits interchangeably with the upper half of the flask to be used in processing the denture, (2) a duplicate of the master cast, and (3) an additional set of the same mold and shade of stock teeth. From these, a spare set of dentures may be made in which both the arrangement of teeth and the wax-up will be an exact duplication of the original. This service will be welcomed by patients who cannot function in their occupation in case of loss or breakage of their dentures, as well as by the dentist who serves these patients.

Rebasing and Relining of Dentures.—The relining or rebasing of old dentures is simplified by having a flexible rubber surface in the upper half of the mold. When rebasing into new acrylic resin, the denture can be flasked without the steps

of first removing the teeth from the denture and waxing them back into position. After the investment has set, the flask may be separated into its halves without heating, since the flexible half of the mold allows the denture to slip out. The teeth may then be heated, removed, and placed back into the matrix side of the mold, and the remaining old acrylic resin can be burned off the cast. The denture is thus made ready for processing with new acrylic resin.

When relining a denture, it may be flasked as soon as the new cast has been made in the corrected impression. The flask may then be separated without heating and the denture teased off the cast. This allows all modifications to the old denture base to be made while it is off the cast and out of the flask. The denture can then be repositioned accurately in the matrix side of the mold and relined with new acrylic resin.

ADVANTAGES OF THE TECHNIQUE

Wax does not penetrate the silicone rubber surface of the mold during the boil-out, as it may do in a plaster mold, so that complete wax removal is made relatively easy and more certain.

The need for painting an alginate tinfoil substitute on the matrix side of the mold and around the denture teeth is eliminated. This removes the possibility that a film of alginate will be left on the teeth, resulting in a poor union between teeth and resin and the consequent loosening of teeth or the developing of crevices around the necks of the teeth.

TABLE IV. CHANGES IN VERTICAL OPENING RESULTING FROM PROCESSING (HEAT-CURING ACRYLIC RESIN NEEDING NO TRIAL PACKING)

DENTURE NO.	PIN OPENING (MM.)	DENTURE NO.	PIN OPENING (MM.)
1a	0.6	7a	0.5
2a	0.4	8a	0.3
3a	0.0	9a	0.0
4a	0.2	10a	0.5
5a	0.4	11a	0.6
6a	0.4		

Porcelain denture teeth are not subject to breakage or splitting by packing the flask or by deflasking the cured denture.

Dentures processed on the casts are recovered from the mold by merely separating the flask into its two halves with a knife blade. The time and skill required for deflasking are greatly reduced.

There is a clean separation of the carved surfaces of the denture from the mold every time without special precautions. The process of finishing and polishing the denture is greatly simplified and consumes much less time.

Because of the excellent accuracy of silicone rubber in reproducing carved contours and the complete absence of any plaster debris or surface roughness on

the denture as it is removed from the flask, much wider utilization of preformed plastic patterns for waxing buccal and labial contours may develop. This would save additional waxing and finishing time.

The processing of acrylic resin to partial denture castings can be done more easily in many cases, in that minute surface undercuts in the investment of the cast in the bottom half (drag) of the mold will not prevent separation of the mold.

There seems to be much less tendency for denture teeth to loosen from the silicone rubber mold than from a plaster mold during the boilout.

USE OF HEAT-CURING ACRYLIC RESIN IN LAYERED SILICONE MOLDS

A pilot study was done to determine the practicability of utilizing heat-curing denture acrylic resin in the layered silicone rubber mold.

After standardizing the procedure for processing dentures in self-curing acrylic resin by the layered silicone rubber mold technique, it was logical to explore the use of heat-curing denture acrylic resin in the same technique. There was no reason to believe, from a theoretic standpoint, that heat-curing acrylic resin could not be used successfully. Since trial packing is not done with this technique, two brands of resin not requiring trial packing were selected for the study.*

The same methods of evaluating results were used as in the original controlled study, i.e., positional occlusal indices to note individual tooth movement and measurement at the incisal pin to detect changes in vertical opening due to processing.

TABLE V. CHANGES IN VERTICAL OPENING RESULTING FROM PROCESSING (HEAT-CURING ACRYLIC RESIN NEEDING NO TRIAL PACKING)

TYPE OF MOLD	NUMBER OF CASES	MEAN OPENING AT INCISAL PIN (MM.)	RANGE (MM.)
Layered silicone matrix*	11	0.36	0.0–0.6

*The upper half of the mold, which holds the teeth and forms the matrix for the polished surfaces of the denture, consisted of a layer of silicone rubber vulcanizable at room temperature backed by sufficient dental stone to fill the flask.

Results of this pilot study (Tables IV and V) indicate that heat-curing acrylic resin needing no trial packing gives excellent results with the layered silicone rubber mold technique. In fact, the step of packing the dentures is less critical from the standpoint of timing when heat-curing acrylic resin is used. Therefore, a dentist trying the technique for the first time would have less chance of encountering difficulty if he used heat-curing acrylic resin.

On the average, there was an increase of 0.2 mm. of incisal pin opening with heat-curing acrylic resin, as compared to the results with self-curing acrylic resin.

*M&M Fluid Pak Denture Acrylic and Microlon Cross Linked Denture Acrylic.

The reason for this is not clear, but it may be due to some factor in processing, such as the application of external heat to the acrylic resin or the effect of a water bath on the gypsum portion of the mold.

SUMMARY

A controlled study was conducted in which 106 dentures were fabricated of self-curing acrylic resin, using silicone rubber as an investing agent in the matrix side of the mold. Occlusal accuracy obtained with a layered silicone rubber mold was markedly superior to that of the usual method of processing in split molds made of gypsum products. A flexible silicone rubber surface in the matrix portion of the mold affords many advantages in the fabrication, rebasing, and relining of dentures. In addition, it provides an accurate and practical method for making identical extra dentures for a patient.

A pilot study was made to determine the practicability of utilizing heat-curing acrylic resin in layered silicone molds.

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REBASING COMPLETE DENTURES USING INFRARED HEAT

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THE USUAL RELINING PROCEDURE often leaves a great deal to be desired. A good union between the old acrylic resin of the denture and the new resin which is added is difficult to obtain. Also, release of internal stresses as the old resin is reprocessed tends to cause it to warp. Self-curing resin has the additional disadvantages of being porous and lacking in color stability. The following procedure is an attempt to solve the relining problem by the use of infrared heat.

PROCEDURE

The critical parts of the denture, such as the hard palate, sharp ridges, borders, etc., are relieved in the usual manner. All undercuts are removed from the tissue surface so that the flask can be separated after the denture is invested. The resin of the old denture must be properly contoured at the gingival line so that the investment material will lock the denture teeth in place. This prevents the teeth from being loosened or pulled out during the removal of the denture-base material. A wax interocclusal centric relation record is made to ensure proper position of the denture during the making of the impression. Six to eight holes are drilled in the palate of the upper denture, and the impression is made with a zinc oxide–eugenol impression material.

An artificial stone cast is poured in the impression, and the denture is invested in the bottom half of the flask so that the occlusal surfaces of the teeth will be approximately 10 mm. from the top of the flask. The denture is flasked entirely in artificial stone since plaster of Paris will not withstand the required temperature. After the stone has set, the flask is separated and the excess impression paste is scraped out of the inside of the denture.

The top half of the flask, which contains the denture, is placed in the oven with the lid side facing up. The infrared element is about 120 mm. above the flask in the oven (Fig. 1). The position of the flask is most important. Previous attempts to remove resin in this manner have been made by heating from the denture side of the flask. This technique burns the resin and fails to soften it sufficiently to allow easy withdrawal of the mass from the flask. By heating through the flask and the thin stone investment to the denture teeth, the heat is directed to the critical retention pins and diatoric holes without raising the temperature of the mass of denture-base material to the combustion level. This procedure can be used only with porcelain teeth, because acrylic resin teeth would be destroyed.

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HEATING PROCEDURE

The oven is preheated to 450° F., and the flask is placed in it for 30 minutes. At the end of this time, the resin should be in a rubbery state. The flask is removed from the oven and placed on an asbestos top table.

The softened acrylic resin is removed with pliers by first grasping the labial flange and pulling it slowly upward, then grasping a buccal flange and lifting it slowly upward. The acrylic resin is given time to pull away from the pins of the anterior teeth and out of the diatoric holes of the posterior teeth. After one side of the resin has been loosened, the other side is treated similarly. If the temperature has been properly controlled, the acrylic resin should come away from the teeth cleanly and in one piece. Occasionally, a tooth will pull loose from the stone investment, but it can be replaced in proper position. Cold air or cold instruments *must not* be used on the porcelain teeth while the flask is hot, to avoid checked or broken teeth.

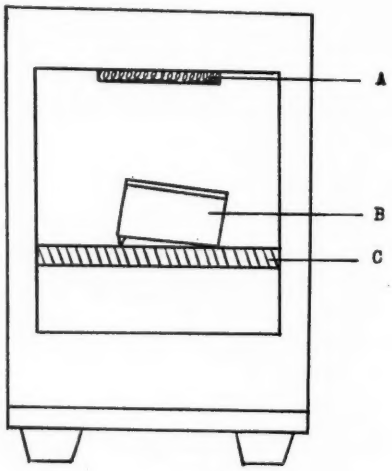

Fig. 1.—Infrared oven with the door removed: *(A)* the infrared element; *(B)* the top half of a flask in the oven; *(C)* an asbestos board shelf. The top of the flask must be 120 mm. from the infrared element.

After the flask has cooled, the mold is packed with new acrylic resin. There is little warpage and no line of demarcation where new and old material would have been joined. Also, the completed denture looks exactly like the old denture and little finishing is required.

TESTS FOR CORRECT DUPLICATION

A plaster of Paris index for the occlusal surfaces of the denture teeth was poured before the rebasing process was begun. Then the teeth on the duplicated denture were fitted into the index after processing to determine changes in tooth position. The change in tooth position was no greater than that of curing a new denture from the wax-up stage.

Four samples of artificial stone, two of the mix before heating and two of the same mix after heating, were tested for crushing strength to determine how much breakdown occurred during the heating period. The difference was not significant.

CONCLUSIONS

Approximately 200 upper and lower dentures have been rebased by means of the infrared heat technique with no more problems than those occurring with curing of new dentures. Clinically, the procedure was successful when adequate care was used. There is need for further work on oven design, dimensional changes of the denture base during the heating process, and effect of the heat on the investment. Perhaps a more suitable investment material can be used to avoid breakdown.

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COLORING MATERIALS FOR DENTURE-BASE RESINS

Part I. Research Necessary for Their Acceptance

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MANY PROSTHODONTISTS ARE SEARCHING for new and better colors for tinting denture-base resins. The dentist depends upon the industry for much of the research and development of dental materials and accepts or rejects these materials after using them clinically. The dentist seldom knows the exact content of many of the materials but uses them at face value.

I have undertaken the selection of colors which may be acceptable to the dental profession (Table I). The problem is difficult, for there are a number of factors to be considered. First, dentures come under the jurisdiction of the Food and Drug Administration. As such, all denture materials, including the coloring agents, should be certified by the Administration. Second, the colors should be readily miscible with the acrylic resins. Third, they should be nontoxic, nonirritating, and noncarcinogenic. Fourth, the colors should be relatively stable and light fast. Fifth, there should be a range of colors extensive enough for blending purposes.

In addition to the regulations by the Food and Drug Administration, certain states have laws concerning the use of coloring materials in foods. Coloring matter is used extensively in the preparation of foods. The maximum limit of arsenic as As_2O_3 for all food colors is 0.0001 per cent. Only a trace of other heavy metals precipitable as sulfides is permitted, and no barium lakes are allowed. Also, a food color may be added in an amount not to exceed 2 grains per pound of food.[1] It is estimated that 0.02 per cent of coloring matter is sufficient to color the denture-base material in complete dentures.

OBTAINING COLORING AGENTS

Obtaining suitable coloring agents is a project in itself. Letters to the National Bureau of Standards and to the Department of Health, Education, and Welfare produced only a small amount of quoted information concerning colors.

The color manufacturers themselves have considerable information concerning the properties of their commercially prepared colors. Only a few of the colors are acceptable by or meet the standards, and limited information is available concerning the colors used in foods, drugs, and cosmetics through the manufacturer, *The Color Index,* and the *Federal Register.* Apparently, colors have not been certified by the Food and Drug Administration specifically for use in dental preparations because

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TABLE I. DRY COLORS USED IN THIS PROJECT

NUMBER	DESCRIPTION
5	Mercury sulfide, vermilion red
9	Biebrich scarlet red
12	Chromium oxide, green
13	Brilliant red toner, 15-T-24
14	Flaming red toner, 23-8849
15	Fastolux green, 64-8500
16	Fastolux blue, 48-E-11
18	C geranium lake, No. 1111
19	Radiant red, 37-T-52
20	D and C red, No. 36
21	D and C red, No. 35
22	D and C red, No. 30
23	Cosmetic red oxide (purified Fe_2O_3)
24	Purified carbon black
25	Lithol rubine toner, 19-3505
26	Cadmium red, deep
27	Cadmium yellow
30	Hansa yellow 10 G toner
31	Heliogen green toner
32	Heliogen blue K toner
28	Napthol red D toner (did not incubate)
29	Napthol red L toner (did not incubate)

The numbers not listed represent colors that were discarded as not acceptable. Certain other colors probably will be eliminated upon completion of this project.

of limited research in the field. Many colors were obtained through distributors, manufacturers, and retailers.

A research project of this kind involves many areas outside the realm of dentistry. Consultations were held with persons in their various specialties. It was decided that no conclusive proof could be derived from the use of small laboratory animals in determining allergic reactions. The toxicity and carcinogenic factors of the colors should be checked according to recognized methods and procedures as set down by the Food and Drug Administration.

INCORPORATING COLORS IN ACRYLIC RESIN

Polymer samples containing 0.1 per cent coloring agent were prepared for this investigation. By making the resin sample highly concentrated with the color material, small amounts could be used for testing. In certain instances when the color powders were light in weight, the proportion was too great and the acrylic resin would not take up all of the color material. In one instance, this excess powder interfered with the polymerization of the resin. The colors were incorporated in the clear acrylic resin by the use of the ball mill (Fig. 1). Colored acrylic resin disks and control samples were processed in the usual manner.

LEACHING EFFECTS OF WATER

Thirteen of the cured acrylic resin samples were tested for leaching properties: No. 5 mercury sulfide, No. 8 geranium lake, No. 9 Biebrich scarlet red, No. 10

ultra blue, No. 12 chromium oxide, No. 13 brilliant red toner, No. 14 flaming red toner, No. 15 Fastolux green, No. 16 Fastolux blue, No. 17 lemon metallic yellow, No. 19 radiant red, No. 23 cosmetic red oxide, and No. 25 Lithol rubine toner.

The disks were weighed on an analytic balance and then immersed in 50 ml. of distilled water at pH 7 in Petri dishes. The water was checked on the colorimeter,* using a No. 54 filter† for a deflection of the null point which would indicate coloring matter in the water. The disks were incubated for 7 days at 37° C.

The disks were removed from the water, wiped dry, allowed to dry further in the incubator for 4 hours, and then placed in a desiccator over calcium chloride for 16 hours. The water was brought back to the original 50 ml. volume and checked for color with the colorimeter. The disks were reweighed and the loss in weight recorded. The water was concentrated to approximately 5 ml. for further study.

A slight clouding was noted in the supernatant of three of the samples. These three colors and their colorimetric readings were (1) No. 13, with a reading of 12, (2) No. 25, with a reading of 14, and (3) No. 8, with a reading of 61.‡

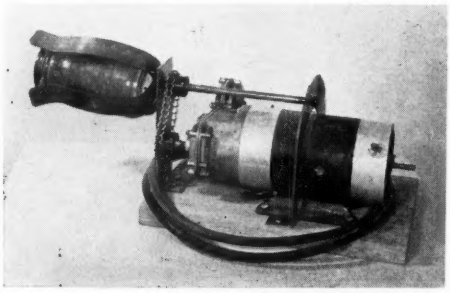

Fig. 1.—The ball mill incorporates the test colors into the acrylic resin.

LEACHING EFFECTS OF SALIVA

Twenty acrylic resin samples were cured, powdered, and passed through a 100 mesh sieve; 50 mg. of this powder was placed in a test tube with 3 ml. of saliva at pH 7. The test tubes were sealed and placed on a shaker in an incubator. The shaker was used to keep the resin granules in intimate contact with the saliva during the incubation period. The specimens were incubated for 72 hours at 37° C.

The test tubes were transferred from the incubator to the centrifuge, where they were spun for 10 minutes at 3,000 r.p.m. The supernatant was decanted and its appearance recorded. A 3 ml. sample of saliva was carried through the same process as a control.

The residue in all samples appeared to be coated with a foreign matter, probably mucin. The residue was shaken with 6 ml. of a buffer solution to dissolve the mucin. This was done on the assumption that the mucin might retain some of the coloring matter. The preparation was centrifuged to separate the solids from the

*Klett-Summerson.
†Green.
‡Tests made through cooperation of Pacific Chemical Laboratories, Inc., San Francisco, Calif.

liquid. The appearance of the supernatant was recorded. The buffer solution was a 0.001M borate solution adjusted to pH 9.

Seven of the samples tested with saliva developed a cloudy supernatant upon being centrifuged the first time: No. 12 chromium oxide, No. 15 Fastolux green, No. 16 Fastolux blue, No. 24 purified carbon black, No. 25 Lithol rubine toner, No. 31 Heliogen green S toner, and No. 32 Heliogen blue K toner. No. 16 showed only a slight clouding effect.

After placing the buffer solution on the residue, dissolving the mucin, and again centrifuging the samples, No. 12 remained cloudy; all other samples were clear. This evidence indicates that the leaching of color material is done by the saliva rather than by the mucin (Table II).

The test tubes and their contents were stored in a refrigerator at 8° C. pending color photography. Five days later, the samples were arranged for photographing and a decided change had taken place in the appearance of the supernatant. The color sample of saliva had darkened as had most of the other samples. However, four of the samples remained clear and apparently unchanged: No. 30 Hansa yellow 10 G toner, No. 23 cosmetic red oxide, No. 18 C geranium lake No. 1111, and No. 5 mercury sulfide. Had the coloring matter stabilized the saliva?

Three other samples showed only a slight clouding: No. 25 Lithol rubine toner, No. 19 radiant red, and No. 22 D and C red, No. 30.

The pH of the saliva was checked at this time and had risen to 8.1 at the lowest to 8.85 at the highest. Apparently, there is no correlation between the clearness of the supernatant and the pH as indicated.

TISSUE RESPONSE TO COLORING AGENTS

The concentrated color specimens were tested on the oral mucosa. Impressions were made, casts were made of artificial stone, and complete palatal coverage prostheses were constructed. One-half of the prosthesis was made of clear acrylic resin

TABLE II. INCUBATION OF COLORED ACRYLIC RESIN SAMPLES IN SALIVA

INCUBATION PROCESS AND DETERMINATION	CLEAR	SLIGHTLY CLOUDY	CLOUDY	DARKLY CLOUDY
Quantities of 50 mg. 100 mesh powder in 3 ml. of saliva at pH 7 incubated for 72 hours at 37° C.; then centrifuged at 3,000 r.p.m. for 10 minutes				
Appearance of supernatant by number of color	5, 9, 13, 14, 18-23, 26, 27, 30, C	16	12, 15, 25, 31, 32	24
Quantity of 6 ml. buffer solution added, shook, and centrifuged at 3,000 r.p.m. for 10 minutes				
Appearance of buffered supernatant	5, 9, 13-16, 18-27, 30-32, C		12	

and the other half of an acrylic resin with a concentrated color, No. 26 deep cadmium red. The prostheses were worn by volunteers at the dental school. The condition of the oral mucosa was noted at the time of insertion and again at regular intervals of 24 hours. No change in the appearance of the oral mucosa was perceptible after 10 days.

CONCLUSIONS

Coloring matter is a substance commonly used in foods, drugs, cosmetics, and medical and dental preparations. A limited number of coloring materials are acceptable for these purposes.

No definitive information is available regarding the safety of specific coloring materials for use in denture-base resins. Some coloring materials are apparently being used without the benefit of certification.

It is possible for the coloring material to be leached out of the acrylic resin by the action of the saliva. However, the fact that a color does leach is not evidence that it is harmful. The cadmium red and cadmium yellow did not leach in saliva.

There has been no inflammation or irritation under prostheses containing a coloring agent when worn by volunteer subjects.

I wish to recognize W. Epstein (allergy), T. Burbridge (pharmacology and experimental therapeutics), Charles Hine (toxicology and cancer research), D. Collins (dental pathology), Joseph Mitchell (dental materials), Howard Myers (oral medicine and pharmacology), V. Hurst (microbiology), Louis Strait and Michael Hrenoff (Spectographic Laboratory, School of Pharmacy), S. Riegelman (School of Pharmacy), and George Hughes (Chairman, Division of Prosthodontics, School of Dentistry) for their assistance in this project. All are members of the faculty of the University of California Medical Center.

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A PLEA FOR MORE RESEARCH ON DENTURE-BASE MATERIALS

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SOME OF THE MANY DEFINITIONS of "fit" are: "coincidence of parts in contact," "tightness of adjustment of adjacent parts," "to conform to or cause to conform to," "to be so adjusted in shape, size, etc."

I believe these definitions cover what the dentist attempts to do when he makes an impression for a denture. Impression making for construction of dentures has been developed to a very high degree of perfection. *Seldom* is trouble with dentures the result of inaccurate impressions. Of course, this applies only to dentists who understand the fundamentals of impression making and who have developed a high degree of skill. A denture constructed from an accurate impression will fit if the other procedures are properly carried through. *But,* will it at the same time give comfort to the patient? The answer is not always. Unfortunately, "fit" and "comfort" are not synonymous. When the patient is not comfortable, he says, "The denture does not fit." The dentist, upon examination, may determine that it *does* fit. Thus, he finds himself with a denture that fits but a patient who is not comfortable.

PRACTICAL ASPECTS OF FIT

Many of us wear shoes that do not fit because we cannot be comfortable with shoes that do. One size larger than the shoe that fits, worn with a cushion inner sole together with soft, heavy socks, will give comfort. Shoes that once were worn in comfort cannot now be tolerated. What has happened? The shoes that were worn in comfort have not changed, but the feet have. Once we could wear the heaviest, stiffest boots, hunting shoes, army shoes, or brogans. Now, we not only must have shoes that are actually too large, but the leather from which they are made must be soft and pliable.

Is there not an analogy between these shoes and the denture that fits but which causes much discomfort? The tissues of the feet are not as young, well-nourished, or tolerant as they were formerly. The feet must be "fitted" into "cushions" held in place by shoes.

By this analogy, I desire to call the attention of the dental profession to the brutal treatment we administer in the name of denture service. There are patients who *cannot* wear dentures that fit, perhaps for the same general reasons that some people cannot wear shoes that fit.

EFFECTS OF DENTURE SERVICE

Just what happens to patients when denture service is rendered? The soft tissues of the jaws vary greatly in thickness and blood supply among different patients. In some persons, the soft tissue is very thin and sensitive. It is spread over bone, the surface of which is *always rough.* This roughness varies with the individual. On this highly sensitive membrane with a hard, rough, irregular surface of bone to support it, another hard, roughened, movable, irregular surface is adapted. The sensitive tissue is thereby squeezed, pinched, and confined between two hard, rough surfaces. Teeth are placed on one of these hard, rough, movable surfaces, and the patient is expected to be comfortable. This is called denture service. Is this physiologic treatment? I know of no other part of the body that is treated with comparable cruelty.

What is the answer to this problem from the point of view of constructing dentures? About 12 years ago, the American Denture Society program was devoted largely to "Dentures for the Senescent Patient." In the discussion following one of the presentations, it was stated that "the next great step in denture work will have to be taken by the manufacturers of denture-base materials."

PATIENT REACTION

A patient related the following story:

> More than 20 years ago my upper and lower (vulcanite) dentures were made and put in immediately after the removal of my teeth. I never had an adjustment of them. They were perfectly comfortable, and I could eat anything I wanted. About 6 months ago, they began to crack, so I asked a dentist if he could "reproduce" my upper denture, removing the old "plate" part, replacing it with the new material, without changing the fit or tooth arrangement. He said he could and he *did,* and they were just wonderful again. Soon after that, the lower denture cracked so badly that I asked him to do the same thing to it that he did to the upper one. He said he *could* do it but persuaded me that a new lower denture would be better. I've tried to be cooperative, but the new lower denture hurts so, food gets under it so badly, and the dentist has spent so much time grinding and adjusting it without improvement that I am discouraged. I do not know what to do.

Then she said, "This new lower denture does not leave room for me to put in one of my liners." I found that the many years of her success were due *not* to the dentist's superior skill but to a drug store "cushion" which she replaced every day. From this patient's viewpoint, this new lower denture did not fit. From my viewpoint, after examining the tissues of the lower jaw and the denture, it did fit. It fitted much more closely and snugly than the old lower denture which lacked so much fitting the gums that there was adequate space for the cushions which made her comfortable and happy.

EFFECT OF SOFT LINERS

Some patients have as many as five complete upper and lower sets of dentures. Some of them have a history of traveling from dentist to dentist, but always with the same disappointing results. They remain uncomfortable and unhappy, often

depressed and resentful. Most of these dentures were well made and good looking. When to one set of the dentures was added a lining of one of the soft but very temporary materials, the patient returned in 3 to 5 days beaming with hope and joy and reported, "Doctor, this is the first time since my teeth were removed that I have enjoyed eating and have been entirely comfortable." Now the anticlimax. The patient must be told that we have no material like this that even approaches permanency. He has to be told that any denture we make for him will be of a hard material and, therefore, will not feel the same as this temporary lining feels.

NEED FOR A NEW MATERIAL

If there was a material for cushioning dentures (similar to the temporary liner) that would retain those soft, compatible properties as long as 1 year, most of the chronic complaints in denture service would be eliminated. Can such a material be produced? It would be embarrassing to say it cannot be done in this age of scientific achievement. A chemist has made the statement that "research has now reached the point where we decide what we want, need, and would like to have, then we just produce it."

This chemist was referring to the paint industry, but if his chief interest and research had been in denture-base materials, and if dentistry had expressed a desire for a soft lining material for dentures that would be compatible with the physiologic condition of the mouth tissues and would retain these desirable qualities for at least 1 year, I believe he would have produced it. Even if we had to replace it once a year, it would still be a great success.

In the dental profession, there are qualified men who have done research in this field, but the two such products I have used are lacking in two respects. First, they are not soft enough. Second, they do not retain the softness they do have long enough, they become hard, and the surface becomes cracked, rough, and irritating to the mouth tissues in a short time.

Paffenbarger[2] stated: "In the United States a large variety of substances are sold to the public for the relining of dentures. In many instances these reliners contain a polymer, such as methylmethacrylate, vinyl acetate or a cellulose derivative, combined with a plasticizer such as glyceryl triacetate, dibutyl phthalate or acetone. Reliners containing plasticizers or solvents adversely affect the denture base resin (Caul and Stanford).

"The use of soft relining resins on artificial dentures has been advocated. So far, all those used in the United States have had poor adherence to the denture base and have hardened and discolored after a few months' use. Plischke's report on the use of an unsaturated polysilane mixed with powdered quartz or glass appears optimistic. Time will tell how long the desirable properties remain."

My experience with two very temporary soft materials convinces me that the cause of denture discomfort in the *great* majority of cases is not a faulty impression, faulty registration of relationships and movements of the mandible, faulty occlusion, or tooth arrangement. Instead, it is the lack of a denture-base material that is compatible with the physiologic requirements of the mucous membrane on which the

dentures rest. Technique and skill are not lacking. Dentists lack suitable materials. In many instances, they have assumed responsibilities and blame when they should not have done so, unless they are to be blamed for not producing proper denture-base materials. If enough dentists agree that such a material is needed, and a united appeal is made for research in this field, I believe that the desired material will be produced. I have so much confidence in the ability of our scientists that I refuse to believe it cannot be done. It is our obligation. We owe it to our patients.

The next great step in denture work must be taken by the manufacturers of denture-base materials.

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REMOVABLE PARTIAL DENTURES

THE TRANSITION FROM NATURAL TO ARTIFICIAL TEETH

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THE WAY IN WHICH THE TRANSITION was made from natural to artificial teeth looms large as a factor in the failure of prostheses and in difficulties encountered with troublesome prosthetic patients. In questioning patients with unsatisfactory prosthetic restorations, it was revealed that (1) teeth were removed without the benefit of immediate or subsequent replacements and (2) complete dentures were planned for the patient without probational periods with partial denture replacements.

COMPLETE DENTURES

In many instances complete dentures must be prescribed to correct infection, malfunction, or a displeasing appearance. However, it is not what is prescribed but rather the manner in which the prescription is filled that may account for the difference between the uneventful, smooth transition from natural to artificial teeth and a transition filled with psychologic and physical trauma. Trauma will be proportional to the sensitivity of the patient. In serving a highly sensitive patient, reactions and results are not predicated mainly on what is done but on *how* it is done, *when* it is done, *where* it is done, and *by whom* it is done.

I have little to say to the dentist serving the nonsensitive patient. My concern is for the sensitive patient and for the sensitive dentist who serves such a patient.

COMMENTS ON SENSITIVITY

There are two categories of sensitivity for the prosthodontist to consider: (1) sensivity due to immaturity and (2) sensitivity that results from hyperperception.

Read before the Tennessee State Dental Association in Memphis, Tenn.
This article is being published simultaneously, by agreement between the editors, in the *Journal of the Tennessee State Dental Association* and THE JOURNAL OF PROSTHETIC DENTISTRY.

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The immature adult is sensitive to situations that would not bother the normal adult. The immature person is easily annoyed, easily offended, and wears his feelings on his shirt sleeves. The slightest provocation causes him to feel neglected, wronged, and slighted.

Sensitivity from hyperperception is due to superawareness and to unusual perception of nuisances and shades and degrees of significance and meaning. These individuals appear to be perfectionists who are highly critical of what they do and what is done for them. They generally have a low threshold to pain and are aware of pressures unfelt by the average person.

TYPES OF SERVICE

The three phases of service in treating patients are (1) to determine the condition, (2) to decide what can be done, and (3) to execute the treatment planned. The first two phases of this service involve diagnosis in the structural, the biologic, and the psychologic categories.

Diagnostic Service.—The objectives in a detailed diagnosis are to determine (1) the structures the patient possesses with which and upon which to build dentures, (2) the capacity of the patient to use this equipment, and (3) the willingness of the patient to use this equipment and capacity.

A careful analysis of the structural, biologic, and psychologic factors must be made and a prescription based on these findings to bring about an amicable termination of each prosthetic relationship.

IMPORTANCE OF THE DISCUSSION

No animal in its natural environment outlives the loss of its teeth. Modern man is able to survive edentulousness primarily because of the artificial methods of food preparation before ingestion.

Dentistry has the know-how to substitute adequately for the lost physical equipment essential to masticate prepared foods and restore pleasant appearance. However, more knowledge and better procedures are needed to ease the transition and lessen the feeling of toothlessness on the part of the patient. An edentulous state often causes psychic as well as somatic repercussions which may be violent or mild, depending on the prescribed procedures and on the personality of the patient.

Edentulousness is bad enough. However, "nondentulousness" is nearly intolerable except by a recluse. Nondentulousness is the condition in which an individual has lost the natural teeth and has not mastered the technique of using artificial teeth.

Nondentulousness is risked if the dentist agrees to render a patient completely toothless before he has demonstrated the capacity to wear removable partial dentures comfortably. Noxious functional habits such as clamping, rubbing, tongue thrusting, and unilateral chewing in eccentric positions should be corrected with removable partial dentures. The periodontal membranes of the remaining teeth assist in treatment by better support and retention.

A CASE HISTORY

A 48-year-old patient had the habits of bruxism and clamping. The remaining natural teeth were mobile and tender, and with a little encouragement, she would have had them removed. She was a sensitive, high strung individual.

I was not responsible for her present dental condition, but I would have been involved had complete dentures been prescribed before her noxious oral habits were treated by the removal of the physical and psychic factors. With additive partial dentures, she was taught to keep the teeth apart and lightly feel the tongue between them. Her family was instructed to check on the "masseter bulge," since the angle of the mandible became quite prominent when she would unconsciously clamp down on the teeth. She was referred to a doctor of psychosomatic medicine to ferret out a possible psychogenic factor.

TOOTH FACTORS AND MOUTH CONTOUR

Persons react deeply to dental problems because the teeth and their enveloping bone support the mouth to an attractive fullness. A pleasantly contoured mouth has a strong appeal, especially to the opposite sex. To mar the mouth of the sensitive person is to deliver a tremendous blow to self-esteem.

IMPORTANCE OF TIMING

The impact of an event upon one's life depends upon the duration of the event and when it occurs. To lose the teeth late in life, when many contemporaries are losing theirs, causes reactions different from those resulting when teeth are lost early.

The element of duration usually acts to cushion the impact of an event upon the personality. When a loss (like the loss of one's hair or its color) occurs gradually over many years, the personality has time to make the necessary mental adjustments with the least amount of mental turbulence and trauma. Mental trauma is the feeling of physical inferiority and loss of self-esteem, self-regard, and zest for living.

The facts of edentulousness can be fairly well handled, thanks to technical know-how. However, the feeling of toothlessness felt by the patient must be minimized. Feelings have a greater personal effect than conditions. How one reacts or feels about personal and environmental facets determines his personality, for one is what he is because of his feelings far more than his thoughts. A feeling of toothlessness is likely to be mentally associated with the loss of vigor, youth, and stamina. The common phrase "to put teeth in a law, etc." hints at this mental association.

The dentist should look into the mind of the patient first and classify him, as House* recommended, as philosophic, exacting, hysteric, or indifferent. Insight into the mind of the patient is gleaned by what he says in conversation and the expression of his face, hands, and body. Note if the individual has temperance in his speech and countenance, and discern if his expressions are mild, moderate, or extreme. Is he calm and considerate, or is he agitated, unfriendly, and prejudiced?

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*M. M. House: Lecture at a "Prosthetic Conference" at the University of Minnesota, Minneapolis, Minn., 1923.

It is always safer to inject the element of time in rendering a patient toothless, but it is imperative to do so when dealing with intemperate, hostile, agitated, and generally prejudiced individuals.

The masticating apparatus develops in time as well as in space. We are born with ten fingers, ten toes, two eyes, etc., which grow in size but do not increase in number. However, we are born toothless and a score of years is required to bring the teeth and their associated structures to a state of full development. The mechanism is not fully developed until the third molars erupt and align themselves. Nature has seen fit to inject the fourth dimension, the element of time, into the development of the masticating apparatus.

Therefore, when planning the demolition of the dental arch, it may be wise to employ the element of time. The physical condition of the teeth may warrant their immediate removal, yet for many individuals, the necessity of caution will counsel delay.

ADDITIVE REMOVABLE PARTIAL DENTURE

Complete edentulousness may be postponed through the use of an additive removable partial denture. Thus, the personality is given an opportunity to adopt the dentures while the mouth tissues are given time to adapt themselves to their presence. The procedure of permitting a patient to be partially or completely toothless for any length of time is generally outmoded, for physical, physiologic, and psychologic reasons.

PHYSICAL REASONS FOR IMMEDIATE REPLACEMENTS

Physical factors for replacing missing teeth include (1) disuse atrophy of the bony base, (2) unfavorable trabeculation of the repairing bone, and (3) possible damage to the ligaments surrounding the temporomandibular joints.

Disuse Atrophy.—When teeth are missing, the mucoperiosteum fails to transmit the stimulation of compressive stresses to the underlying bone in the absence of a denture. As a result, disuse atrophy takes a toll in cancellous bone. The end result is not only less mass of bone but also narrower foundational width of the maxillae.

Unfavorable Trabeculation of Repairing Bone.—Two periods in the life cycle of bone are extremely important in determining its internal architecture and its external form: (1) the period of development and (2) the period of repair following injury.

Allowing the absence of a denture after extractions is passing up a unique opportunity to favorably orient the trabeculae of the repairing bone so they can most effectively withstand the type of stress that later will be transmitted by the denture.

Damage of the Temporomandibular Joints.—An edentulous patient is prompted to approximate the anterior ridges in the absence of dentures. If this action is continued for some time, it may damage the temporomandibular joints, primarily

the disks. The absence of dentures also sets up neuromuscular patterns that make it difficult to record centric relation and for the mouth to function in centric relation after it is recorded and incorporated in the dentures.

PHYSIOLOGIC REASONS FOR REPLACING TEETH

The physiologic reasons for replacing missing teeth are (1) abnormal functioning of the mouth and mandible, (2) impaired enunciation, and (3) abnormal deglutition.

Abnormal Function.—The muscles of the stomatognathic system need the scaffolding support of the teeth and their enveloping bone for normal function. While there is much more to the mouth and jaws than teeth, teeth are indispensable to normal function. Without teeth, the associated osseous tissue, the muscles and auxiliary muscles of mastication including the tongue, lips, and cheeks, the salivary glands, and the muscles of deglutition cannot function as planned by Nature. The beautifully effective teamwork between the various parts of the stomatognathic system is broken up when the teeth are removed. This teamwork will have to be reestablished when dentures are inserted later. This requires time, effort, and perseverance on the part of the patient, thus complicating the task of getting used to dentures.

Impaired Enunciation.—Enunciation without teeth compels the tongue to use a soft tissue arch composed of the lips and cheeks. The tongue acts as a valve and must press against an arch to effect a partial or complete closure of the air current to provide correct enunciation of the consonants. Considerable annoyance to the tongue results when a new arch of artificial teeth is inserted later.

Abnormal Deglutition.—Normal deglutition suffers in the absence of teeth. To swallow a bolus of food, the mandible must be braced somewhat to elevate the floor of the mouth. Contact of opposing teeth effects the needed bracing action for effective deglutition. When the teeth are not present, the bracing must be done by the buccinator, orbicularis oris, and superior constrictor muscles. This results in abnormal neuromuscular patterns and pathways that may be difficult to correct when dentures are placed later.

PSYCHOLOGIC REASONS FOR REPLACING TEETH

The psychologic reasons for replacing missing teeth are (1) humiliation suffered by the patient because of impaired performance of routine social functions, (2) adverse subjective reactions, and (3) indifference.

Humiliation.—The absence of teeth can be an extremely humiliating experience to a sensitive person. Socially useful and important functions are impaired, such as speech, smiling, laughing, singing, the appearance of one's mouth, and mastication, which the amenities of life compel one to perform in the presence of others. One can sleep alone, but it is difficult to always eat alone.

Adverse Subjective Reactions.—A patient is made aware of the fact that he is now toothless when teeth are removed. However, a prolonged period of nondentulousness (without natural or artificial teeth) forces this awareness of tooth-

lessness into one's inner consciousness. The person gets to feel "toothless," which is a blow to self-esteem. Adverse subjective reactions are kept at a minimum if the objective circumstance of having teeth can be maintained through immediate substitution. The experience is kept out of the subconscious. If a patient continues to look the same with immediate dentures, he is very likely to take the incident in stride.

Serving the Indifferent Patient.—The psychologically indifferent person appears not to be concerned about his appearance. Immediate denture service is imperative in dealing with this type of patient, for he will not persevere long enough to re-establish neuromuscular patterns if the insertion of dentures is postponed.

The problem of treating edentulousness begins with the loss of the first tooth, exclusive of the third molars. If the situation is handled adroitly at this time, it will cease to be a problem. Patients should have a full complement of teeth (natural, artificial, or the combination) at all times. This does not mean that patients who have spaces existing in the mouth should *always* have them filled. There are situations when the occlusion is edge to edge and there is a favorable bone factor conducive to physiologic acceptance of lost structure. Here, it may be unwise to subject the patient to the expense and inconvenience of delayed replacements.

Unless an anterior tooth is involved, a tooth substitute must be "sold"; it is seldom "bought." The following possibilities of neglect in mending the mutilation must be pointed out to the patient: (1) shifting, rotation, and elongation of adjoining and opposing teeth, (2) unilateral chewing resulting in abnormal neuromuscular patterns which later are difficult to undo, (3) speech difficulties caused by a broken dental arch, (4) shifting of the occlusion and an increase of the vertical overlap resulting in temporomandibular joint disturbances, (5) a slovenly appearance to others, and (6) a general attitude of indifference to body care and hygiene.

The type of substitutions to be used depends on the age, personality, and financial status of the patient. Fixed partial dentures are generally indicated for the young. Removable partial dentures have many advantages for those past 40 years of age. If a removable partial denture is indicated, the additive plan should be the design of choice.

CONDITIONS DELAYING COMPLETE DENTURES

Generally, the following make for poor results with a complete denture and indicate its delay when possible: (1) jaw deformities and abnormalities, (2) speech defects, the result partially of abnormal tongue, lip, and cheek action, (3) lack of stamina and health, (4) intemperate or hysteric attitude, (5) indifference to appearance, (6) lack of complete rapport, and (7) the feeling that complete dentures are not more advantageous than the present condition.

Jaw Deformities.—Small maxillae coupled with a large mandible housing an oversize tongue presents a problem in stabilizing the upper complete denture. Such patients should be kept partially dentulous if at all possible. Cross-bite, prognathism, orthognathism, or a deep vertical overlap of anterior teeth generally exists under these circumstances.

Any disparity in the size of upper and lower jaws should be a warning sign to delay edentulousness in the smaller jaw. Under this category of jaw abnormalities should be listed (1) the palatal or mandibular torus, (2) lack of space between tuberosities and retromolar pads, and (3) a flexion (vibrating) line of the soft palate that is far anterior to the tuberosities.

Poor Enunciation.—Patients who mouth their words and have no perceptible structural reason generally make troublesome complete denture patients. This is probably due to their low index of neuromuscular skills. Tongue agility is required to give every word its full phonetic value. Neuromuscular skill must be exercised if complete dentures are to be mastered.

Lack of Physical Stamina, Temperance, and Mental Balance.—Patients who lack the inner braces of good health may find complete dentures a trying ordeal, especially when they are precipitously pushed into this circumstance. The method of using complete dentures is not easily learned in the absence of physical stamina.

Patients who lack temperance and mental balance may be easily troubled by complete dentures. These hysterically inclined individuals have a tendency to exaggerate every difficulty incidental to becoming accustomed to complete dentures.

Indifference to Appearance.—Individuals who are lackadaisic and indifferent to environmental circumstances, including their personal appearance, may be difficult complete denture patients. They are not sufficiently motivated to persevere long enough to master complete dentures. They can be made for such individuals, but the difficulty is to get them to wear the dentures. These patients should be eased into complete dentures through immediate additive removable partial dentures and should never be aware of an absence of natural teeth.

Establishment of Complete Rapport.—Patients should feel that they are in friendly as well as competent hands. A psychologic atmosphere conducive of absolute trust must be created for best results with complete dentures. The task is not only to satisfy the patient with regard to our competence but also to inspire faith in our capacity to help. This factor is needed to counter emotions evoked during the difficult period of adjustment to new dentures. Their acceptance is not a matter of mental evaluation alone, it is an emotional reaction as well.

A patient's acceptance of a program is not always based on comprehension of the facts involved in the situation. The acceptance may be based on as precarious a matter as liking the dentist as a person. Patients are most anxious to like their dentist and also to be liked by him because of the personal, intimate contact that mouth rehabilitation involves.

People differ considerably in their acceptance of complete dentures. Persons who have lost the teeth slowly and naturally (in the sense that the natural teeth loosened) have little difficulty in rehabilitation when complete dentures are made. The person who puts up with loose teeth will endure a loose denture, and all dentures are loose when compared with sound natural teeth. A thicker, less rigid membrane (the mucoperiosteum) attaches a denture to the supporting bone, whereas a thin, rigid membrane (the periodontal membrane) joins the natural tooth to the underlying bone.

Edentulousness is characteristic of older people to be sure, but is it characteristic of old age? Toothlessness is a feature of old age only when the natural teeth fall out of their sockets and are not forcefully removed. Many cases of toothlessness are not natural but intentionally brought about with a pair of forceps.

THE ADDITIVE REMOVABLE PARTIAL DENTURE

An additive removable partial denture is so planned that other units may be added without depriving the patient of the use of the denture for more than a few hours. These additions may constitute an immediate replacement of the condemned natural tooth or teeth. The denture is designed so that its initial metallic parts facilitate additions without seriously jeopardizing the stability and retention of the restoration.

The additive design eases the transition from natural to artificial teeth and also helps promote acceptance of removable partial dentures. One layman, with personal experience and charming wit, defines partial dentures as ". . . a device for losing one's remaining teeth, slowly, painfully, and expensively."

DURABILITY

The factor of cost is coupled with durability. The notion is generally prevalent in the public mind that removable partial dentures soon become useless because of the loss of other teeth. Thus, new partial dentures are needed which, in turn, become unstable when more teeth become untenable in the mouth. So, the questions arise in the patient's mind: "Why partial dentures? Why not face the inevitable now, namely, complete dentures?"

The additive design promotes durability because one of its cardinal principles is the use of all available tooth-bearing and tissue-bearing areas in the mouth. As a consequence, the denture is so stable that periodontal and mucoperiosteal torque is kept well within physiologic bounds. Abutments usually fare well and generally remain firm and serviceable because of the above principle and other factors.

COMFORT

It is often rumored that removable partial dentures are uncomfortable. The old adage that a partial denture is an uncomfortable corridor leading to a complete denture is no longer true.

Pain from partial dentures is generally the result of impingement of periodontal or mucoperiosteal membranes or both. The additive partial denture minimizes impingement because it is so adequately stabilized.

PRINCIPLES OF THE ADDITIVE DESIGN

The principles of the additive design may be grouped into five categories: (1) the utilization of all available tooth-bearing and tissue-bearing surfaces in the mouth as long as it does not permanently interfere with speech and appearance, (2) maximum use of contact bearings on proximal and occlusal surfaces of the remaining

teeth (contact bearings on buccal, lingual, and labial surfaces are employed sparingly), (3) the use of the infrabulge proximal retainers wherever factors of esthetics will allow, (4) the use of rigid broad, ribbonlike connectors instead of bars, and (5) modification of the occlusal pattern with the neutrocentric concept.

Multiple Bearings.—Many partial dentures are designed by the patient instead of the dentist. The patient wants lack of bulk, lightness, and smallness. He may need just the opposite.

The unit system of computing costs also influences the design of partial dentures. Commercial dental laboratories charge on the basis of design; the more retainers and stabilizers used, the higher the cost. As a consequence, there is a tendency to skimp on design to keep cost down. Also, many patients object to the appearance of multiple bearings with metal showing on occlusal and labial surfaces. These factors tend to encourage removable partial dentures with minimal tooth bearings and scant soft tissue coverage.

A removable partial denture is in the hand before it is in the mouth, and often a patient concludes from its size whether or not he will wear it with comfort or annoyance. This erroneous reaction requires prior assurances that the more multiple the tooth bearings and the greater the tissue coverage, the greater will be the area of load distribution and consequent comfort. It should be explained that, in function, a partial denture is subjected to stresses and strains much like a railroad bridge. The design must be mechanically sound to avoid breakdown of supporting structures.

The basic approach of the additive removable partial denture is to harness into service all remaining teeth (with the possible exception of incisors) by the use of occlusal rests. In addition to the primary abutments, other teeth are employed as auxiliary abutments. The use of auxiliary abutments makes it more convenient to add to the denture when the need arises.

Palatal Coverage.—The patient's objection to palatal coverage is often reflected in the design of the denture. For example, a narrow palatal bar is employed or, what is mechanically inferior, two separate, unilateral removable appliances are used.

Broad, ribbonlike connectors are far more desirable than bar connectors for rigidity, support, and retention. A ribbonlike connector usually covers a tortuous surface, a surface in more than one plane. Such coverage results in greater rigidity for a given mass of metal than that fashioned into a narrow bar. Ribbonlike connectors add to the total available denture-bearing area, and, when in close contact with the mucosa, they also increase retention through interfacial surface tension.

Proximal and Occlusal Bearings.—The most convincing argument for proximal and occlusal bearings is that these surfaces are used for this purpose in the natural dentition. The tongue, cheeks, and lips contact lingual, buccal, and labial surfaces of the teeth, yet they do not bear upon them in the same sense that the teeth in function bear upon each other on occlusal and proximal surfaces. Clinical observation supports the reasoning that it is safer to limit bearings to proximal and occlusal surfaces.

Whenever possible, retainers and stabilizers should not be placed on lingual and labial surfaces of the remaining natural teeth. However, on occasion, lingual and buccal surfaces of trirooted molar teeth are contacted for additional bracing purposes.

Infrabulge Retainers.—Clasp arms approach undercut areas from above or from below. The direction is determined with the cast in hand and not as seen in the mouth. The design is of suprabulge form when the clasp arm arises from the occlusal cone of the tooth and travels downward to contact the undercut. The design has infrabulge form when the clasp arm arises from the denture base and travels upward to reach the undercut. Infrabulge retainers, such as Bonwill, Roach, and embrasure-saddle clasps, are gentle to abutment teeth and contribute much to the success of the additive design. Conventional suprabulge clasps, such as the Akers, Nesbitt, etc., types, grip abutments so effectively that the loss of a single abutment may jeopardize the stability and comfort of a removable partial denture.

A principle of the infrabulge design first employed by Bonwill is that retainers and stabilizers should be independent from one another and should be joined separately to the denture base. This separation of retainers and stabilizers causes less strain upon abutment teeth. During the initial insertion of the denture, suprabulge clasp arms are not present to interfere with the seating of occlusal rests. Then, again, infrabulge retainers may be adjusted without jeopardizing the seating of the occlusal rests. The additive principle requires that consideration be given to the possibility that a tooth-borne removable partial denture may become a free end denture by the loss of one of the abutment teeth. In such an eventuality, infrabulge retainers may save the appliance because of their stress-breaking tendency.

Abutment teeth that contain infrabulge retainers are subjected to less torque when the dentures settle. The denture is permitted to move laterally without dragging the abutments with it when infrabulge retainers are used.

Ribbonlike Connectors.—The additive partial denture rules out the use of palatal and lingual bars. In general, the additive denture also buries the whole idea of the skeletal design.

Broad, ribbonlike connectors that cover the middle third or more of the palate provide a sufficient stress-bearing area for other units to be comfortably added to the denture. Palatal coverage is well tolerated by the average patient, provided the glandular tissues in the posterior part of the mouth are not covered. In time, palatal coverage causes less annoyance to the tongue than the skeletal design. Palatal coverage is sturdy and rigid and survives many an extraoral mishap without deformation.

An added advantage of broad palatal connectors is that the patient is conditioned for the coverage of a complete denture. The conditioning occurs at an earlier age when adaptation is easier.

NEUTROCENTRIC OCCLUSAL CONCEPT

The design of any partial denture should be greatly influenced by the kind of occlusal pattern employed. The additive design is no exception. If the occlusal

pattern gives rise to considerable transverse and horizontal force, more bracing elements are essential. Bracing action is obtained by boxlike occlusal recesses and by placement of struts on buccal and lingual surfaces.

Functioning inclines are not essential for mastication. The dentist may employ a monoplane occlusal pattern and pitch it parallel to the underlying ridge plane. Other tooth factors, such as position, proportion, and number, may also be favorably modified. Neutrocentric occlusal concept is a term coined to designate such departures from the anatomic occlusal pattern.

In developing the occlusal pattern, attempts are made to neutralize inclines, centralize tooth position, reduce the area of occluding surfaces, alter the pitch, and reduce the number of dental units. These procedures are done to increase the stability of both the natural and artificial teeth. The problem of stability is intimately related with reducing horizontal forces on both natural and artificial teeth.

An occlusal pattern should be used that will help maintain stability of the denture in the event that the remaining natural teeth are lost and the removable partial denture is converted into a complete denture. The word "stability" is important in the above sentence, and it should not be confused with "retention." A denture may exhibit retention but not be stable. In fact, many of the obscure difficulties with complete and partial dentures are related to stability. The presence or absence of retention is overt, for no denture is likely to be taken from the dental office unless it stays up or down. However, the stability of a denture is covert, and this factor cannot be fully evaluated until the denture has been used for some time.

CONVERTIBLE REMOVABLE PARTIAL DENTURE

The convertible denture, or that for pre-edentulousness, is used when three teeth or less remain in the mouth. The flanges and palatal form closely resemble those of a complete denture. The tooth factors of position, proportion, pitch, form, and number simulate those employed for complete dentures. Thus, the removable denture can be converted easily to a complete denture when retaining the few remaining teeth becomes undesirable.

CONCLUSION

The methods of rendering a patient edentulous may make the difference between a smooth, uneventful end result or one that is loaded with psychologic as well as physical trauma. Traumatic transition from natural to artificial teeth leads to psychologic repercussions as well as to physical pain and dysfunction.

A smooth, uneventful transition not only results in a better denture foundation physically and physiologically by maintenance of the normal neuromuscular patterns, but also, psychologically, such a transition diminishes the feeling of toothlessness. The latter may well be associated with the feeling of having lost one's youth and attractiveness.

It is not alone *what* is done that is important but also how, when, where, and by whom it is done when dealing with the sensitive, highly emotional, immature, or indifferent patient. Rendering patients edentulous by means of additive or convertible removable partial dentures does much to make the practice of prosthodontics amicable and pleasurable.

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THE BAR JOINT MANDIBULAR DENTURE

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THE PROBLEM OF STABILITY AND RETENTION of mandibular complete dentures is far from a solution that is universally satisfactory, especially for patients with extensive alveolar bone resorption. The smaller the number of mandibular teeth that remain, the more thoughtfully these teeth should be treated. When only two natural teeth remain, a method of preserving them is imperative. This situation occurs most frequently in three arrangements (Fig. 1): (1) two spaced teeth in the anterior region, such as the two cuspids, (2) two adjacent teeth in the anterior segment, such as one cuspid and the adjoining lateral incisor, and (3) two spaced teeth in one posterior segment of the dental arch, such as a second molar and a premolar.

The bar joint denture preserves a small number of residual teeth as long as possible. The bar splints the shortened and crowned abutment teeth, retains and partially supports the complete denture, and, together with the sleeve contained in the denture base, acts as a joint.

PRINCIPAL OF SHORTENING TEETH

A statically unfavorable ratio exists between the length of the crown and the length of the root in most older patients. The supported root is relatively too short (Fig. 2). Often, in addition the long isolated crown is not stabilized by adjacent teeth. Therefore, residual teeth often respond to masticatory stresses with increased mobility. However, in many instances, teeth with decayed crowns, even with the loss of vital pulp tissue, and mobile teeth can be used as abutments if the coronal parts are reduced and the roots are protected with Richmond copings (Fig. 3).

Radical shortening of such teeth results in a statically more favorable ratio of the length of the crown to the length of the root and avoids further breakdown of the periodontal structures. Endodontic treatment is performed at the same time if the remaining teeth are vital. In this stage, a pulpless tooth with a well-functioning periodontium is much more important than a loose tooth with a vital pulp.

PRINCIPLE OF SPLINTING

Two teeth standing separately, such as the two lower cuspids, are splinted with a straight bar attached to the two Richmond copings. The bar is positioned as close to the residual alveolar ridge as possible. Both teeth become more firm and are safer abutments periodontally than if left standing alone (Fig. 4).

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A. *B.* *C.*

Fig. 1.—Different groups of remaining teeth permit the construction of the bar joint denture. *A*, Two spaced anterior teeth. *B*, Two adjacent anterior teeth. *C*, Two spaced posterior teeth.

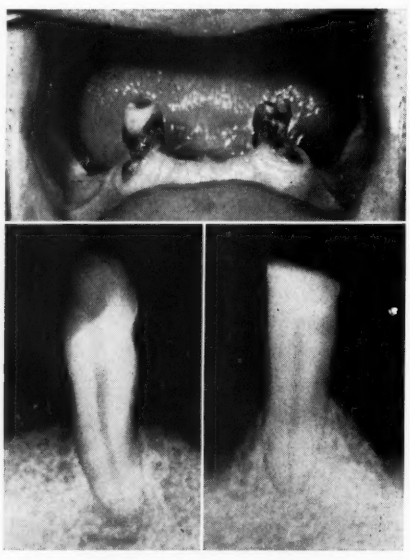
Adjacent teeth are splinted by soldering the copings together; the bar is mounted on top of the copings (Fig. 5).

ELEMENTS OF THE BAR JOINT

The composite bar joint is made up of the bar and the sleeve (Fig. 6). The bar consists of a straight wrought wire that is egg shaped in cross section. The bar connects and splints the abutment teeth by attachment to the copings and, at the same time, functions as the shaft part of a hinge joint. The bar is always oriented with its tapered edge adjacent to the residual alveolar ridge. The bar measures 3 mm. on its major and 2.2 mm. on its minor diameter; the "microbar" measures 2.3 mm. and 1.6 mm., respectively (Fig. 6).

The open-sided sleeve, which is contained invisibly in the denture base, snaps over the bar when the denture is inserted. The sleeve is a 0.2 mm. thick gold alloy

A.



B. *C.*

Fig. 2.—*A*, The two remaining cuspids exhibit extensively decayed crowns. *B* and *C*, Roentgenograms reveal supporting bone only along a small part of the roots.

Fig. 3.—The remaining teeth are radically shortened, and the roots are protected with Richmond copings.

Fig. 4.—The two Richmond copings with parallel pins are splinted solidly by the bar. The bar is notched somewhat mesially to the copings to free the gingival crest. The open-sided sleeve, cut obliquely at the ends for the same reason, is fitted tightly between the two copings.

sheet. The sleeve fits the broad top of the bar exactly but does not quite touch the tapering sides of the bar with its elastic flanges.

FUNCTIONS OF THE BAR JOINT

The bar and sleeve joint gives retention and guides the movements of the denture relative to the abutment teeth. The sleeve supplies functionally adequate retention, and when the teeth are out of contact, there is a vertical gap of about 1 mm. between the roof of the sleeve and the top of the bar (Fig. 6).

From this initial (resting) position, the bar and sleeve joint permits three possible movements of the denture: (1) during vertical depression of the denture, the entire sleeve is translated toward or upon the bar, (2) during unilateral depression of the denture, only the more depressed end of the sleeve touches the bar, and (3) rotation about the bar as an axis is possible for approximately 10 degrees in either direction from the resting position. Rotation is limited only gradually by the elastic flanges of the sleeves (Fig. 6).

MATERIAL

The alloys for all components of the bar joint should provide the requisite mechanical characteristics, including permanent elasticity of the sleeve. I use a high quality, platinum-containing alloy of gold.*

*The Scientific Dental Co., Ltd., Los Angeles, Calif.

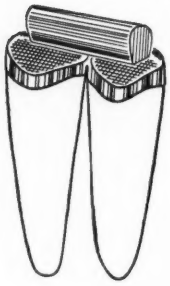


Fig. 5.—The bar is mounted on top of two adjacent abutment roots.

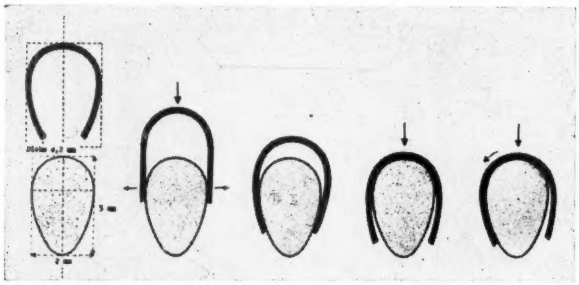
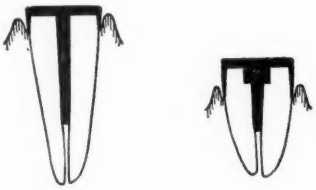


Fig. 6.—The bar joint in schematic cross section shows, from left to right: the parts disassembled, insertion of the denture, the position of rest, perpendicular depression of the whole denture, and rotation about the bar as an axis.



A. *B.*

Fig. 7.—*A*, Low Richmond copings with long pins are used on long roots. *B*, Richmond copings on short roots require, in addition to short pins, a central inlay preparation and a higher preparation of the root for adequate retention.

PROCEDURES FOR CONSTRUCTION

Construction of a bar joint denture when only the lower cuspids remain illustrates the procedures.

Endodontic treatment is followed by shortening and preparation of the abutments, fitting of pins (which must be parallel), making of individual copper band impressions with pins, and temporary sealing of the roots. Copings are waxed on copper-plated dies, invested, and cast around the pins, which are then soldered together. Short roots with consequently short pins should be prepared somewhat higher and possibly with an interior reinforcing inlay preparation to achieve good retention of the copings (Fig. 7).

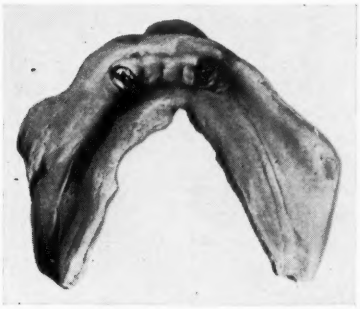
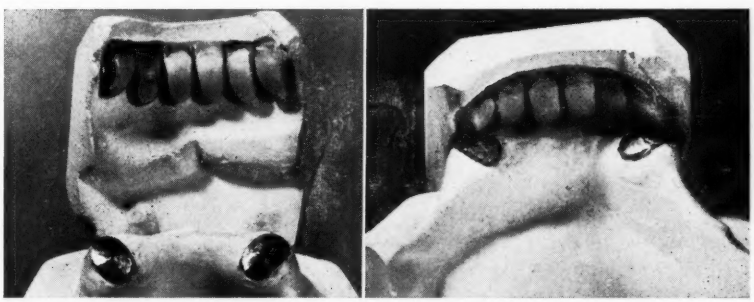


Fig. 8.—The copings are positioned in the individual plaster impression.

An individual acrylic resin impression tray is prepared on a preliminary lower cast. Sufficient space is provided for the Richmond copings. The tray is fitted in the mouth, and the borders are developed in the same manner as for complete dentures.

The Richmond copings are placed on the abutment teeth, and a plaster impression is made. The copings are positioned in the impression (Fig. 8).

An impression of the upper jaw is made if a maxillary complete denture is to be constructed at the same time. After the casts are poured, occlusion rims are constructed. The jaw relation records are made, and the teeth are selected.



A. *B.*

Fig. 9.—*A*, The labial plaster key contains the anterior teeth. *B*, The key is positioned on the cast.

The teeth are positioned in the occlusion rims. Acrylic resin teeth are used in the lower anterior segment so they can be arranged directly above the residual alveolar ridge. The try-in is completed.

The position of the lower anterior teeth is recorded with a labial plaster core, and the anterior segment of the wax pattern is removed. The teeth are left fixed in the plaster key (Fig. 9). The bar is fitted between the two abutment copings on the cast and positioned horizontally with the tapered edge toward and close to the alveolar ridge, at right angles to the line bisecting the angle formed by the posterior alveolar ridges (Fig. 10). An oblique position of the bar impairs correct function

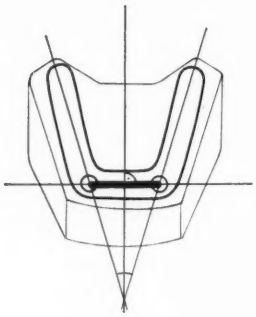
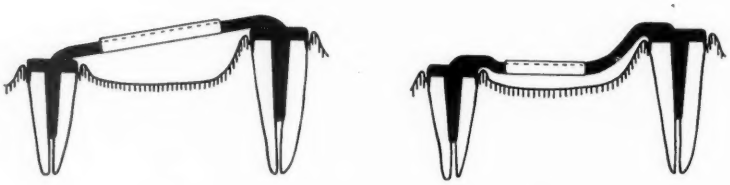


Fig. 10.—The bar is positioned perpendicularly to a line bisecting the angle between the posterior ridges.



A. *B.*

Fig. 11.—The horizontal positioning of the bar and sleeve is important. *A*, The incorrect position. *B*, The correct position.

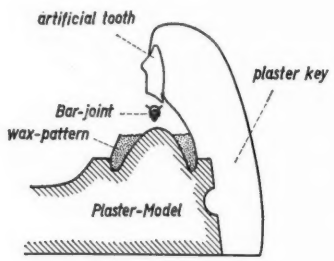


Fig. 12.—A schematic cross section of the anterior part of the cast illustrates the position of the bar and sleeve relative to the alveolar ridge and the artificial teeth.

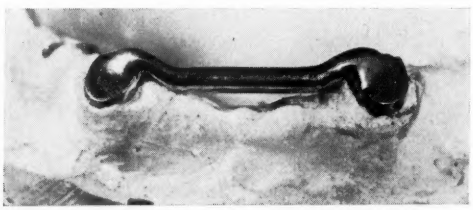


Fig. 13.—The soldered bar-copings framework is reseated onto the cast.

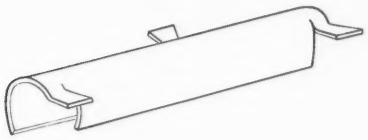


Fig. 14.—Three dovetailed flaps are cut into the open-sided sleeve and bent up to supply retention in the acrylic resin denture base.

Fig. 15.

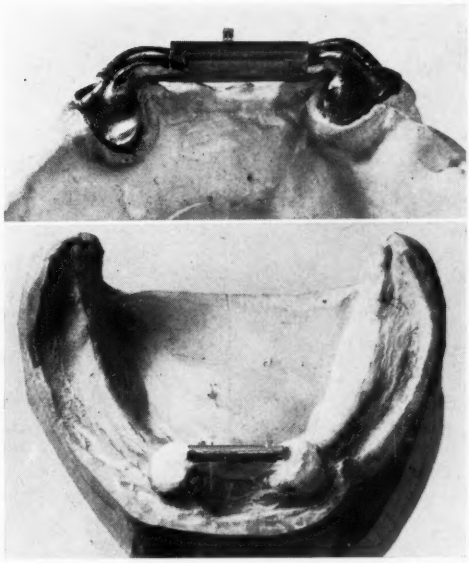


Fig. 16.

Fig. 15.—The sleeve is fixed temporarily on the bar in the resting position by an intermediary wire.

Fig. 16.—The copings are covered with a 1 mm. layer of plaster prior to curing the denture. Unimpaired functioning of the bar joint is not possible when the denture base fits the copings closely.

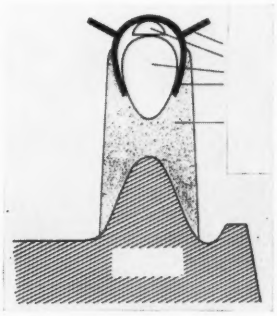


Fig 17.—An enlarged schematic cross section of the bar joint shows, from top to bottom: retentive flaps of the sleeve, the intermediary wire, the bar, the sleeve, and the plaster which assures the correct position of the sleeve during curing of the denture and creates space that is needed for proper functioning of the bar joint.

of the joint (Fig. 11). The microbar is used only where there is insufficient interocclusal clearance for the regular size bar.

The bar is temporarily attached to the cast with sticky wax or self-curing resin, and the plaster key containing the anterior teeth is carefully repositioned. The position of teeth determines whether or not the bar must be repositioned further lingually (Fig. 12).

The final position of the bar and the copings is determined on the cast and secured with plaster. The bar and copings are solidly soldered and replaced on the cast, and the clearance between the bar and the mesial gingival papilla is determined (Fig. 13).

An appropriate length of the metal sleeve is cut, and dovetailed flaps are bent up for retention in the denture base. No soldering is required, and thus the elasticity of the sleeve is fully maintained (Fig. 14). An auxiliary wire is placed between the top of the bar and the sleeve to maintain their position during the curing of the denture (Fig. 15).

Fig. 18.

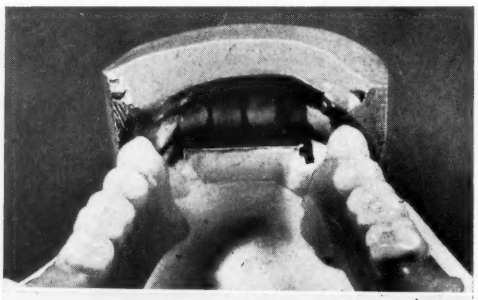


Fig. 19.

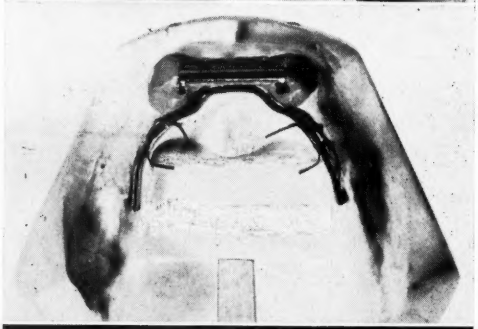


Fig. 20.

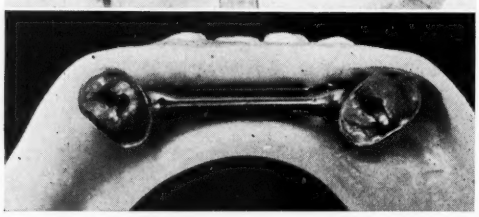


Fig. 18.—The anterior teeth are definitely repositioned with the plaster key.
Fig. 19.—A small lingual bar is adapted to reinforce the denture base.
Fig. 20.—The functioning and the retention of the bar joint are tested outside the mouth.

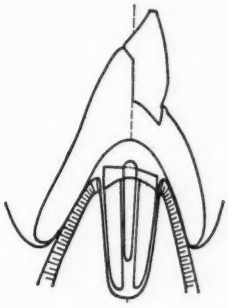


Fig. 21.—The denture base above the abutment copings must be sufficiently excavated to allow free movement of the bar joint.

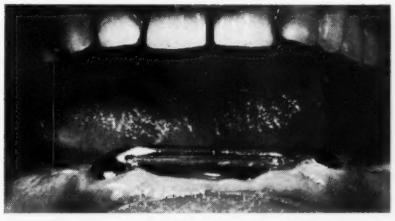


Fig. 22.—The cemented copings with the connecting bar are placed in the mouth.

Fig. 23.—The elastic flanges of the egg-shaped sleeve may be tightened with a suitable pointed instrument for better retention of the finished denture.

The Richmond copings are covered with a 1 mm. layer of plaster (Fig. 16), and the space between the alveolar ridge and the flanges of the sleeve is also filled with plaster to maintain space in the denture base (Fig. 17).

The anterior teeth are repositioned on the cast using the plaster key (Fig. 18), and the wax pattern of the denture is completed with a reinforcing lingual bar (Fig. 19). The flasking is completed in the usual manner. After processing, the denture is carefully deflasked; especially the bar must be cautiously removed from the sleeve.

The anterior lingual part of the denture is made as thin as possible. Free functioning of the joint is tested outside the mouth with the bar-copings framework inserted into place in the denture base (Fig. 20). The denture base may need additional relief above the Richmond copings (Fig. 21).

The bar-copings framework is trial fitted in the mouth; slight grinding of the pins may be necessary to ensure correct, parallel seating (Fig. 22). Roentgenographic examination of the abutments and temporarily seated copings is required to establish the proper fit.

The free flanges of the sleeve are tightened if the finished denture lacks adequate retention (Fig. 23). The occlusion is carefully balanced.

Adjustment appointments are given the patient for 1 and 4 weeks after insertion. At the same time, the instructions to the patient regarding cleansing are repeated.

DYNAMICS OF THE BAR JOINT DENTURE

The mandibular bar joint denture is a complete denture on a fixed partial denture (microbridge) supported by terminal abutments. The bar and the sleeve

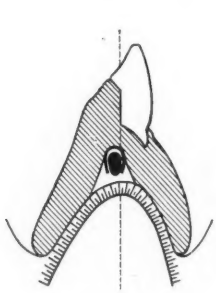


Fig. 24.

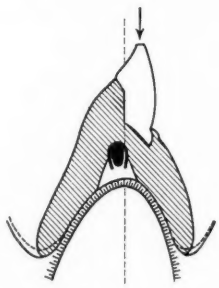


Fig. 25.

Fig. 24.—A schematic cross section shows the anterior part of the completed denture in its resting position. Note the vertical gap of about 1 mm. between the roof of the sleeve and the bar.

Fig. 25.—A schematic cross section shows the anterior part of the completed denture in a vertically depressed position. Note that the "roof" of the sleeve touches the top of the bar.

Fig. 26.—In a recently inserted bar joint denture, there is a vertical gap of about 1 mm. between the bar and the roof of the embracing sleeve. Unilateral depression of the denture results in hinge movement about the axis *(R)* somewhere in the ridge of the undepressed side. Only the more depressed end of the sleeve touches the bar, while the opposite end remains near its resting position. The rotating system may be called a one-sided lever system.

serve as the connecting elements of the two dentures. The fixed partial denture consists essentially of the bar that is attached to the abutment copings. This constitutes the male part of the complete restoration. The female part, the sleeve, is contained in the base of the removable complete denture.

The insertion and removal of the denture are accomplished easily by the patient. The elastic flanges of the sleeve readily snap over the egg-shaped bar and give the denture adequate retention.

Position of Rest.—The inserted denture rests on the alveolar ridges and is entirely tissue borne. In this rest position, the roof of the sleeve is about 1 mm. above the top of the bar (Fig. 24).

Vertical Translation.—When the denture is depressed vertically, it presses upon the resilient mucosa of the posterior ridges. The entire length of the sleeve approaches and then is depressed onto the bar transmitting part of the masticatory load onto the abutment teeth (Fig. 25). Thus, in the final phase of vertical depression, the denture is supported partly by the abutments and partly by the soft tissue. A well-retained and well-guided denture that transmits part of the masticatory load to anterior abutment teeth is appreciated by the patient, particularly during use of the anterior teeth.

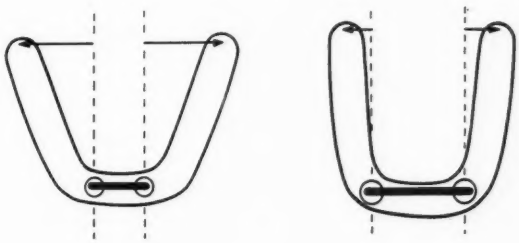


Fig. 27.—A long bar ensures better guidance and retention of the denture than a short bar. Note the favorable lever diagram of the more nearly parallel posterior ridges *(A)* as compared to the diverging posterior ridges *(B)*.

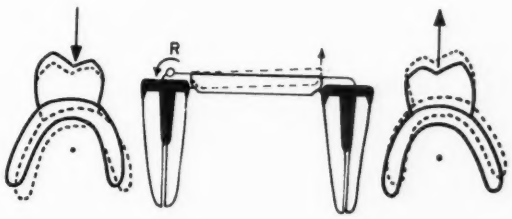


Fig. 28.—After the process of adaptation, the denture has embedded itself into the tissue approximately 1 mm., and the sleeve rests on the bar in its entire length in the resting position at this time. The hinge axis of a unilateral depression of the denture is now the coping of the depressed side, while the opposite side of the denture is slightly lifted from the mucosa. The rotating system may now be called a two-sided lever system.

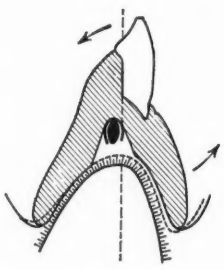


Fig. 29.—The posteriorly depressed denture rotates about the bar as its axis.

Unilateral Depression.—The bar and sleeve permit the unilateral depression of the denture when it occurs during unilateral mastication. The denture rotates about the undepressed ridge as an axis, and the corresponding end of the sleeve remains near its rest position. Only the loaded end of the sleeve is depressed toward the bar (Fig. 26). The longer the bar and the sleeve can be made, the better are the retention and the guidance of a denture subjected to such rotation (Fig. 27).

In the course of 6 to 12 months, the denture embeds itself approximately 1 mm. into the mucosa, allowing the sleeve to rest directly upon the bar. The axis of rotation in unilateral depression of the denture is then transferred to the loaded end of the sleeve, and unilateral depression results in a slight lifting of the denture from the mucosa of the opposite side (Fig. 28).

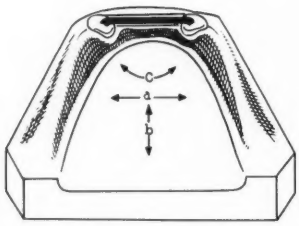


Fig. 30.—The undesirable movements of the denture are impeded by the bar joint: *(a)* lateral translation; *(b)* sagittal translation; *(c)* horizontal rotation about a vertical axis in the anterior region.

Posterior Depression.—Chewing on the posterior part of the denture results in rotation about the bar, its axis. This rotation is possible about any axis throughout the continuum of axes within the perpendicular translation (Fig. 29).

All of these motions of the denture occur normally during mastication. The egg-shaped structure of the bar joint permits these three movements and guides the denture effectively. However, the construction of the bar joint eliminates undesirable movements of the denture which are ultimately destructive (Fig. 30).

Lateral translatory movements hasten alveolar atrophy of the posterior ridges. The flatter the ridges are initially, the more care should be taken to impede lateral

translatory movements. A correctly fitted sleeve that touches both copings makes lateral displacement of the denture impossible.

Forward and backward translations are withstood by the snugly fitting sleeve. Such movements can also be minimized by extending the denture base distally onto the retromolar pads.

Rotation about a vertical axis in the anterior region is primarily destructive to the posterior ridges and impairs masticatory efficiency because the denture escapes the chewing force. Efficiency of chewing and stability of the denture are again to some degree dependent on the length of the bar and sleeve (Fig. 31). Extending the denture base into the mylohyoid region decreases the tendency of the denture to make such rotations.

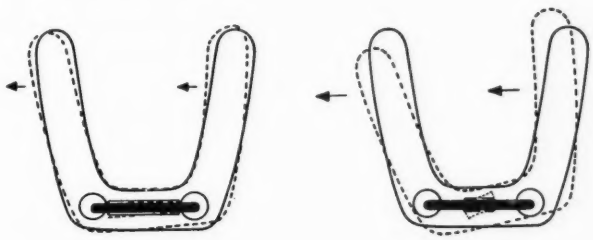


Fig. 31.—A long sleeve *(A)* hinders rotation about a vertical axis better than a short sleeve *(B)*, which may be pried open.

ARRANGEMENT OF THE BAR JOINT

Anterior Arrangement.—The position of the remaining teeth determines the arrangement of the bar in the mandible. The cuspids are the most resistant teeth in the lower jaw. In 57 per cent of the 270 patients for whom the bar joint was used, the two cuspids were the only remaining abutments. Within the group of two spaced anterior abutment teeth, twenty other variations are possible. Throughout this group, the bar is constructed transversely between the spaced abutments.

Within the group of two adjacent anterior abutments, five different situations are possible. In this group, the Richmond copings are joined by soldering, and the bar is mounted on top of them in a transverse direction.

Sagittal Arrangement.—The unilateral location of two or more remaining teeth is considerably less frequent than a bilateral location. The bar is constructed above the lateral alveolar ridge in these situations. The three degrees of freedom of movement of the bar joint remain principally the same (Fig. 32).

Copings on molars generally require no pins in the root canals. An inlay that extends into the pulp chamber is cast as a part of the coping; this assures sufficient retention (Fig. 33).

Diagonal Arrangement.—Diagonal placement of the bar appears possible. However, experience with fractured dentures shows that a diagonal arrangement is statically unfavorable. In these borderline situations, the bar is either bent or attached to the copings so as to attain a transverse orientation of the bar (Fig. 34).

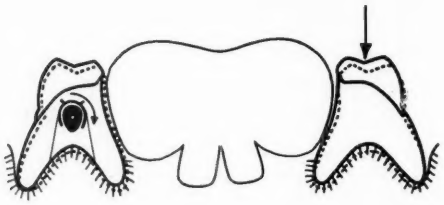


Fig. 32.—A schematic cross section shows a sagittally positioned bar. Unilateral depression results in either a rotation about the bar as an axis or an almost complete transmission of the load to the abutment teeth.

REINFORCEMENT OF THE BAR-COPINGS FRAMEWORK

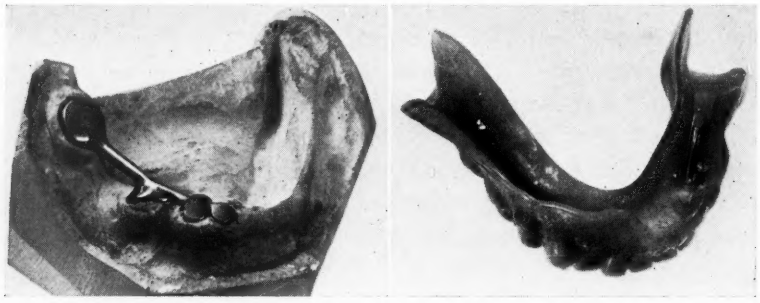
The bar joint denture should not be limited to instances of only two residual teeth. Planning this type of denture when more than two teeth are present helps delay the complete loss of teeth even more efficiently.

Use can be made of additional remaining teeth in various ways, depending on their location. Additional incisor teeth are shortened and their copings soldered to the cuspid copings. The bar may be attached on top of the copings (Fig. 35) or in a lingual position, depending on the amount of space between the opposing teeth (Fig. 36).

First premolars are joined to the cuspid copings in the same way, which substantially reinforces the abutment system. The denture base must be adequately excavated above the premolar copings to assure proper function of the bar joint (Fig. 37).

ESTHETIC ASPECTS

Clasp and stress breaker removable partial dentures have the abutment teeth, clasps or stress breakers, and denture in horizontal sequence. This results in a visible discontinuity between natural and artificial teeth. A vertical depression of the partial denture creates an occlusal step at the junction of artificial teeth and abutment teeth and makes the discontinuity even more discernible.



A. *B.*

Fig. 33.—*A*, A sagittally arranged bar is on the cast. *B*, The corresponding denture contains the sleeve in its base.

The bar joint denture keeps the abutment teeth as well as the bar joint out of view underneath the denture base. Thus one esthetic problem of the usual removable partial denture is eliminated. Furthermore, the continuity of the artificial dentition of the bar joint denture leaves free choice as to size, shape, shade, and arrangement of the teeth to attain the most natural appearance possible.

Remaining cuspids protrude somewhat labially from the residual ridge because of the accelerated alveolar atrophy in edentulous regions of the lower jaw. The position of the cuspid copings may thus be misleading since artificial cuspids usually must be set further lingually. The lingual prominence of the denture base resulting from a bar placed too far lingually irritates the tongue and impairs speech.

The bar joint denture should be built according to approved principles of complete denture construction. Only the precise determination of vertical and centric relation, sagittal condyle paths, and interalveolar line angles permits optimal reconstruction of the dentition both functionally and esthetically.

PSYCHOLOGIC ASPECTS

The incorporation of a foreign body into the oral cavity requires an emotional adaptation which may take more or less time according to age, disposition, and environment of a patient. A complete lower denture with poor retention and inadequate masticatory efficiency will tire a patient not only physically but also emotionally. The resulting feeling of insecurity and inferiority prompts many patients not to wear the lower denture at all.

Fig. 34.—An unusual transverse arrangement of the bar.

The bar joint denture fits this situation perfectly. It is a denture that fills the wide gap between the clasp or stress breaker denture and the complete denture.

The bar joint denture has most of the valuable assets of a removable partial denture: (1) good retention and guidance of the denture and partial stress transmission on an abutment system offer the patient safety and masticatory efficiency, (2) good appearance of the denture permits the patient an unembarrassed contact with his environment, and (3) changing to a bar joint denture delays the necessity for complete dentures for a number of years (Fig. 38).

The immediate advantages of the bar joint denture render the patient's life more pleasant for a long period of time. At the same time, the bar joint denture prepares a patient to adapt more easily to the eventual complete denture. Considering the increasing life expectancy, the need for postponing complete dentures as

long as possible cannot be over emphasized. The drastic and still questionably successful procedures of oral plastic surgery and implant dentures should be limited to otherwise hopeless situations.

STATISTIC ANALYSIS OF TREATED PATIENTS

For a total of 270 patients, bar joint dentures were made. Of this total, 110 patients were re-examined. These 110 patients had a mean age of 57 years and had worn the bar joint dentures an average of 3 years 3 months, but none less than 1.5 years. The examination provided a number of observations.

Dynamics.—Only one of the 250 abutment teeth examined presented distinctly increased mobility. Subjectively, 97 per cent of the patients were satisfied with both appearance and masticatory performance of the bar joint denture.

Abrasion of Root Copings.—The outer edge of most of the root copings showed signs of abrasion, produced by denture rotation about a sagittal or transverse axis which caused intermittent contact and friction between the copings and the base of the denture.

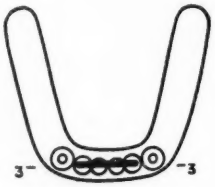


Fig. 35.—The bar is mounted on top of the copings.

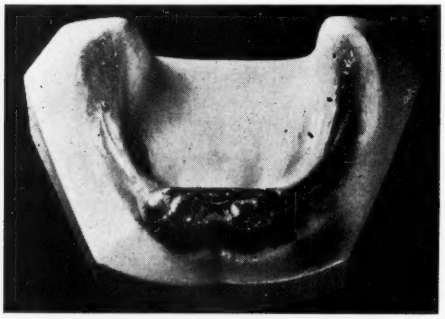


Fig. 36.—The bar is positioned lingually to the copings.

Fig. 37.—The copings on the premolar abutments are soldered to the cuspid copings to reinforce the foundation for the bar.

The amount of abrasion recorded was (1) no abrasion in 3 per cent of the patients, (2) little abrasion in 6 per cent, (3) average abrasion in 74 per cent, and (4) marked abrasion in 17 per cent. The greater abrasion was observed in dentures that had been worn for a long time and had become embedded into the tissues. Thus, the sleeves were riding directly on the bars.

The process of adaptation takes a varying period of time depending on the capacity of the edentulous dental arches to bear loads. The loss of the original vertical distance of 1 mm. between the bar and sleeve occurred in more than 6 and less than 18 months in 95 per cent of the patients.

To avoid unnecessary friction, the original space position of the sleeve and bar should be recreated after 1 year. The space can be obtained either by excavating the denture base over the copings or by repositioning the sleeve within the base, where possible. The sleeve is repositioned by removing the sleeve and the acrylic resin immediately surrounding it from the base. The sleeve is positioned over the bar in the patient's mouth with the auxiliary wire interposed. After the denture has been carefully tried in over the sleeve and bar, an internal plaster key is made of the new relative position of the base and sleeve. The sleeve is incorporated in the base with acrylic resin.

The copings and bar should be constructed of a hard gold alloy.

Fractures.—The incidence of fractures of bar joint dentures is higher in older dentures. The cuspid region is the most frequent site of fracture. Reinforcement of the denture base with a flat, cross-section steel lingual bar reduced the incidence of fractures and cracks from 13.7 to 6.7 per cent.

Behavior of the Mucosa.—Instructions concerning proper care and cleaning of the bar-copings assembly and the denture base should be thorough. Printed instructions should be given the patient immediately after the insertion of a bar joint denture.

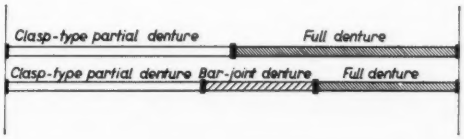


Fig. 38.—Complete dentures are postponed for years by a timely transition from a clasp-borne removable partial denture to a bar joint denture.

Gingival inflammation: Of 110 bar-copings assemblies, 46 were well cleaned, 51 moderately so, and 13 poorly cared for. The degree of inflammation as rated by a PMA index (*p*apillae, *m*arginal, and *a*ttached gingivae) was related inversely to the cleanness of bar and copings.

Four stages were used to rate the degree of inflammation of the mucosa: (1) unchanged, light bleeding on probing only, (2) bleeding on probing and light change of color caused by inflammatory disturbances, (3) bleeding on probing, change of color, and edematous swelling, and (4) necrosis and ulceration. The

examination demonstrated that 57 per cent of the patients were in the first stage, 25.5 per cent in the second stage, 14.5 per cent in the third stage, and 3 per cent in the fourth stage. The mean value of PMA index was 1.63.

More commonly the denture base, being removable, was easier to clean and therefore better cleaned than the bar and copings. Although the cleanness of the denture base does not have a definite effect upon the degree of gingival inflammation, degree was found to be directly related to amount of abrasion found on the copings.

Gingival enlargement: Younger patients not only react to irritation with gingival inflammation more easily but also are more prone to hypertrophic gingival enlargement than older patients. Twelve of the 110 patients examined exhibited gingival enlargement, particularly on papillae between neighboring copings. These enlargements receded when caustically treated with silver nitrate pearls.

Gingival recession: Gingival recession was observed more frequently in older patients. Gingival recession, deepening of gingival pockets, and poor oral hygiene led to secondary decay on denuded abutments in 10 per cent of the 2-year-old restorations. Small amalgam restorations were then placed, and they proved to be adequate.

SUMMARY

A prosthetic technique, the bar joint denture, was introduced. The denture is adapted primarily to the situation with which only a few teeth remain.

This technique has been extensively tested clinically, and this report is based on statistically analyzed results on 270 patients treated and controlled regularly over a period of 8 years.

The basic construction procedures consist of (1) shortening and capping the residual teeth to render the crown : root length ratio more favorable and (2) splinting the abutments with a straight bar affixed to the cemented copings which serves, at the same time, as the bearing shaft for the complete denture.

The sleeve, contained invisibly in the denture base, snaps over the egg-shaped bar when the denture is inserted.

The structure of the bar and sleeve articulation supplies retention of the denture and permits the denture 3 degrees of freedom of movement. The articulation hinders the destructive horizontal displacements of the denture and permits a partial load transmission onto the abutment system.

The bar joint denture offers a transitional solution between the clasp removable partial denture and the complete denture. The bar joint denture is relatively inexpensive and improves the emotional situation of a patient at the brink of needing complete dentures.

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FIXED PARTIAL DENTURES

FACTORS CONTRIBUTING TO TRAUMATIC OCCLUSION

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ONE OF MAN'S MOST COMPLEX dental problems has been loss of the natural dentition through deterioration of the alveolar process supporting the teeth. Many factors, including health, excessive tooth eruption, irregularities in arch form, and habit, have played an important part. In many instances, however, when all of these factors appeared to be negative, otherwise healthy teeth have been lost through what seemed to be traumatic injury to the supporting structures. Those interested in oral rehabilitation of dentitions have seen their restorations succumb at times to this baffling weakness.

CYCLE OF MASTICATION

The cycle of mastication will be analyzed for a possible factor which might contribute to trauma of the periodontium of the posterior teeth, and a means of eliminating that factor will be proposed.

The eccentric movements of the mandible during mastication are extremely varied and follow no specific pattern except when all eccentric movements are restricted by exceedingly steep interlocking inclines of the anterior teeth. When mandibular movements are influenced by these undesirable restrictions, the individual is forced to masticate or cut his food with a chopping, vertical motion.

When there is freedom of lateral movement in eccentric positions, the cycle of mastication in each individual will be varied depending upon the type and resistance of the food being chewed and the degree to which it is broken down. It will vary from a straight vertical movement to a more lateral movement in which the buccal cusps of the lower teeth engage the buccal inclines of the upper teeth, shearing the food as they pass from the lateral eccentric position toward centric position. It has been shown* conclusively that the cycle of mastication does not always terminate at centric position but that the lower buccal cusps may pass beyond centric

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Read before the Greater New York Academy of Prosthodontics, New York, N. Y.

*J. Schweitzer, Ira Klein, and other members of a research committee of the Greater New York Academy of Prosthodontics.

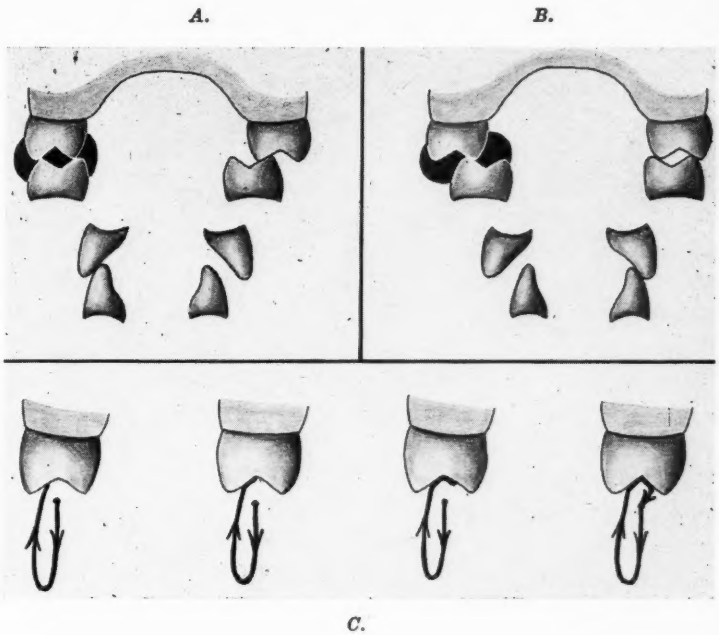

Fig. 1.—The cycle of mastication. *C*, The path of the lower buccal cusp point starting from the rest position and first contacting the working incline of the opposing upper tooth, passing through centric position on to the balancing incline, and then returning to the rest position. *A* and *B*, Contacting tooth surfaces during the mastication of a bolus of food. *A*, At the point of first contact. *B*, At the completion of the cycle of mastication as they appear in a normally balanced occlusion. At the position of first contact, the inclines of the anterior and the posterior teeth on the working side touch simultaneously, broadly distributing the stress. The buccal cusp has passed through centric occlusion on to the balancing incline in its cycle, the muscles of mastication being contracted unilaterally on the working side. The limited number of contacting posterior teeth on that side would be severely traumatized, while the teeth on the opposite side take little if any of the stress. Note that the working incline is nearly parallel to the cycle of mastication, while the balancing incline is nearly at right angles to the closing path.

position and terminate on the balancing inclines of the opposing upper teeth (Fig. 1). It was also shown by McLean[1] in a motion picture presented before the Academy of Denture Prosthetics in 1941 and referred to in published articles. It would seem less plausible that destructive trauma would be experienced in the primary lateral contact, since this contact is normally distributed between all the teeth from the central incisor to the last molar. This is a gliding, shearing contact upon inclines which may be nearly parallel to the cycle of closure. There is an extreme potential of shock and trauma if the lower buccal cusp passes beyond the opposing central fossae, making contact with that surface normally spoken of as the balancing incline. This incline may approximate a plane perpendicular to the direction of the applied force. Visualize a falling body contacting an inclined plane nearly parallel to its line of descent. The impact of this contact might be slight, but if the falling body continues, later contacting a plane perpendicular to its direction of fall, the impact of this second contact would be many times greater than the impact of the first. In natural dentitions, the impact of this primary contact is divided between

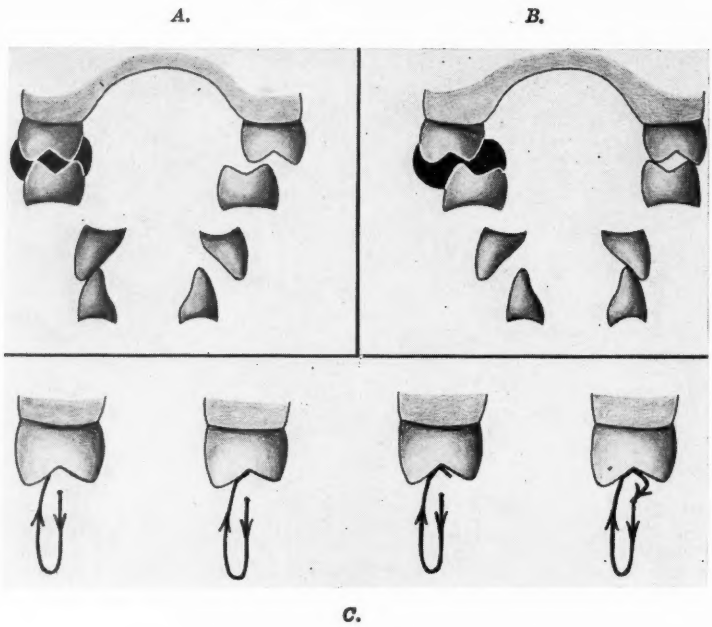

Fig. 2.—The cycle of mastication. *A*, *B*, and *C*, The steepness of the anterior guiding inclines and the posterior working inclines remains the same as in Fig. 1, but the steepness of the balancing inclines has been reduced. As the cycle of mastication passes through centric occlusion, the anterior and posterior working inclines on the opposite side absorb the stress, relieving the balancing inclines from traumatic contact. The unilateral application of muscular force as in mastication might still bring these tooth surfaces into contact or near contact, but the potential destructive traumatic stress would be greatly reduced.

many teeth from the central incisors to the last molars, while a limited number of posterior teeth bear the major impact when the lower buccal cusps pass beyond centric position, on to the balancing inclines. It is these teeth that exhibit the ravages of a traumatic occlusion.

TRAUMA FROM BALANCING INCLINES

I have discussed[2,3] the potential destructive trauma associated with prematurely contacting balancing inclines. This reference has been to nonfunctional side contacts. As the cycle of mastication reaches the position of centric relation, the complete dentition should be in bilateral balance. When the cycle extends beyond centric position, trauma will be experienced from excessively steep or premature balancing contacts on the side of function.

Visualize a dentition that might be described as perfectly balanced. It is balanced in centric position and in all eccentric positions when muscular force is evenly applied bilaterally. With a unilateral application of muscular force, extreme crushing pressure may be applied to the teeth on one side, with little or no stress or pressure being applied to the teeth on the opposite side. This means that although the dentition may be perfectly balanced when the teeth are occluded with an equal, bilateral application of force, they cease to be balanced with a unilateral application of

force. When equal force is applied bilaterally, stress will be distributed bilaterally over a large number of teeth. When force is applied unilaterally, as in the function of mastication, the stress will be absorbed primarily by the teeth on the side where the force is applied. In the perfectly balanced occlusion, the functional contact upon the working inclines will be borne by all of the teeth from the central incisors to the last molars, but if the cycle of mastication extends beyond centric occlusion, the stress of occlusion will be borne entirely by a few teeth posterior to the cuspids, and these may become traumatic contacts because of the fact that this unilateral stress is placed upon a limited number of teeth. The stress upon these balancing inclines is greatly magnified since they are approximately perpendicular to the direction of force. The jaws are closing while contact is being made upon the working inclines. Maximum closure is at centric occlusion. When the cycle of mastication passes beyond centric occlusion, the jaws are forced to separate as the lower buccal cusp glides up the balancing incline of the opposing upper tooth. This forced separation of the jaws is coincidental with the continued application of unilateral muscle force striving to close the jaws. Thus, balancing contacts which might have appeared to be harmless may, with the unilateral application of force, become traumatic, most destructive, and extremely undesirable.

CONTROLLING POTENTIAL TRAUMA

The potential of trauma upon the balancing inclines can be avoided by reducing the steepness of balancing posterior tooth inclines (Fig. 2). I have advocated the reduction of balancing inclines[4,5] and have stated that their steepness is controlled primarily by two factors: (1) the forward inclination of the glenoid fossae and

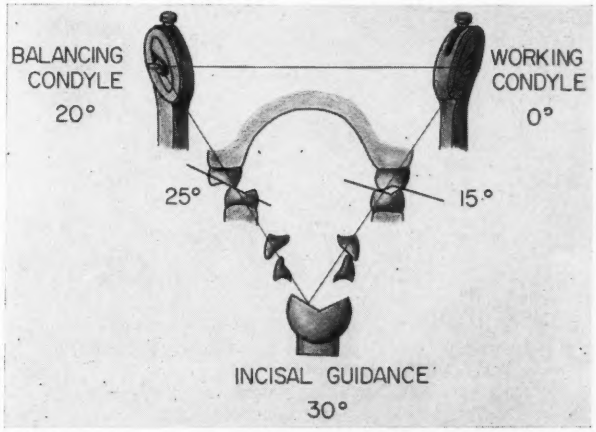

Fig. 3.—The steepness of the working side inclines of posterior occlusal surfaces is controlled by the lateral cuspid or incisal guidance and by the lateral Bennett movement or the rotation of the condyles in the glenoid fossae. These inclines are most often progressively less steep from the first bicuspid to the last molar. The steepness of the balancing inclines on the opposite side is controlled by the steepness of these same incisal or cuspid guide factors and the steepness of the anteromedial inclines of the glenoid fossae. If the incisal guide factors and the glenoid fossae incline were all 30 degrees, the steepness of the balancing inclines would be approximately 30 degrees.

(2) the laterolingual incline of the upper cuspid on the opposite side or the laterolingual inclines of anterior teeth which might be termed lateral incisal guidance (Fig. 3). As an example, if the lateral inclination of the cuspid or incisal guidance is 30 degrees and the anteromedial inclination of the glenoid fossae is 30 degrees, all posterior balancing inclines would be approximately 30 degrees (Fig. 4). If the lateral cuspid guidance is 30 degrees and the condylar guidance is 20 degrees, the balancing inclines would vary from approximately 27 degrees in the bicuspid region to 25 degrees or less in the region of the last molar, the incline becoming progressively less steep on the last molars (Fig. 5). The forward inclination of the glenoid fossae has little or no influence upon the lateral functional inclines of the posterior teeth. The steepness of these inclines is controlled primarily by the lateral incisal guidance and the lateral or Bennett movement of the condyle in the glenoid fossae.

REDUCTION OF BALANCING CONTACTS

I have repeatedly called attention to the destructive trauma associated with premature balancing contacts. The possibility or probability that the physiologic balancing contact under the bilateral application of force may become a pathologic contact limited to a few teeth under a unilateral application of masticating force should be considered.

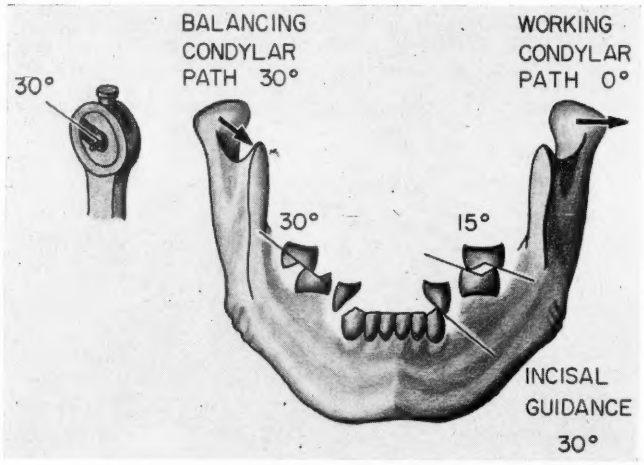

Fig. 4.—The condylar inclination which, together with the opposite cuspid or incisal guidance, controls the steepness of the balancing incline.

A balancing incline, the steepness of which is several degrees less than that of the respective working inclines on the opposite side, might still make contact during the unilateral application of masticatory forces when the cycle of mastication passes beyond centric occlusion. This would lead to the conclusion that the pathologic trauma often experienced on posterior teeth might be eliminated by reducing the steepness of the balancing inclines to a degree that would avoid traumatic contact when the cycle of mastication extends beyond centric occlusion. This consideration

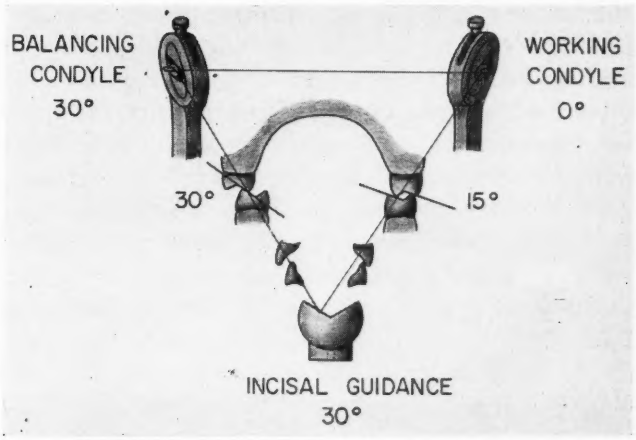

Fig. 5.—A reduction of the inclination in the condylar guidance instrument while the occlusal surfaces are being rebuilt would cause a reduction of the steepness of the balancing inclines without altering the steepness of the working inclines.

should apply in evaluation and correction of occlusion of natural dentitions as well as of occlusions that are being rehabilitated. With few exceptions, the reduction of the balancing contacts of natural dentitions to relieve trauma would be accomplished by reducing the length of the lingual cusp and the steepness of the lingual incline of the upper teeth.

The respective reduction of the steepness of the balancing inclines is easily accomplished while carving occlusal contours in oral rehabilitation. The protrusive condylar inclinations are established on the articulating instrument in the usual manner. The desired lateral and protrusive incisal guidances have been established.

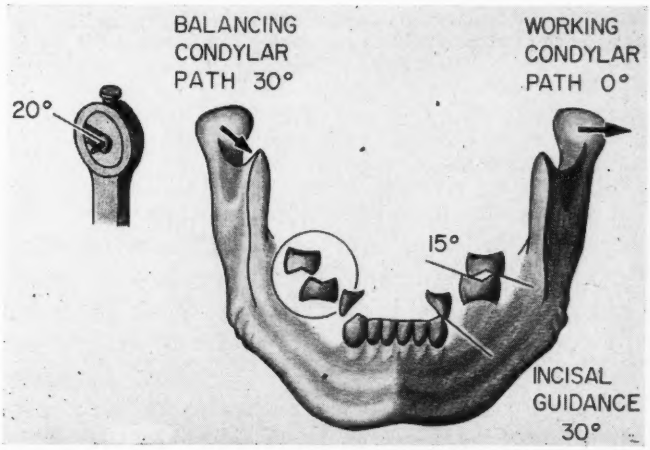

Fig. 6.—When the restorations are placed in the mouth and the cycle of mastication passes through centric occlusion, the working inclines on the opposite side, from the incisors to the last molar, function to absorb much of the traumatic stress that would otherwise be exerted upon the few balancing incline contacts. The proximity of the balancing inclines would be influenced to a degree by the amount of force applied unilaterally during mastication.

The condylar inclinations in the instrument are then reduced approximately 10 degrees. This, as stated before, will have the effect of reducing the steepness of the restored balancing inclines by approximately 5 to 6 degrees in the region of the last molar and probably 3 degrees in the region of the first bicuspid. The balancing inclines of these restorations, when placed in the mouth (Fig. 6), would be freed from contact with an even bilateral application of force, and they would be relieved from contact or the traumatic shock would be greatly reduced during a unilateral application of force associated with mastication when the cycle of mastication passes beyond centric occlusion. This change would have no effect upon the desired distribution of force in centric position, or other eccentric positions, or upon masticating efficiency.

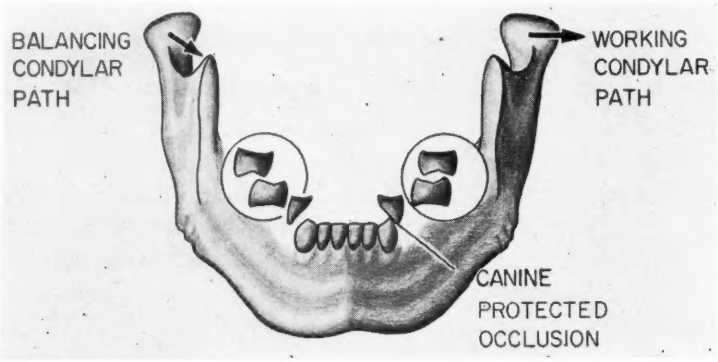

Fig. 7.—The cuspid-protected occlusion accomplishes the desired relief of stress upon the balancing inclines of the posterior teeth, but it places this potential of trauma entirely upon the opposite cuspids. In fact, all eccentric stresses are carried entirely by the cuspids. Teeth which have taken this stress throughout the life of the patient may have developed bone support to withstand the stresses. Such a patient has also developed abnormal chewing habits. When in more normal occlusions the cuspid inclines have been increased to take all other teeth out of contact in the eccentric positions, function is greatly impaired and the loss of the alveolar support of the cuspids through trauma might be expected.

CUSPID-PROTECTED OCCLUSION

It would seem desirable to compare these thoughts briefly with the recently advocated theory of the "cuspid-protected occlusion," as advocated by D'Amico. He observed that in cases in which the cuspid teeth were in prominence, protecting the bicuspids and molars from contact in all eccentric positions, the potential of destructive trauma to all posterior teeth seemed to be greatly reduced or eliminated. It was, therefore, concluded that this was the ideal occlusion, and many of the staunch supporters of the most complicated of the adjustable instruments used in oral rehabilitation have accepted his theory of the cuspid-protected occlusion. In planning complete oral rehabilitation, they have first perfected a balanced intercuspation of the posterior teeth in centric and all eccentric positions, after which the steepness of the guiding inclines of the cuspids has been increased to a degree that precludes functional or balancing contacts of the posterior teeth in all eccentric positions.

D'Amico[6] states: "The canine teeth serve to guide the mandible during the eccentric movements when the opposing teeth come into functional contact . . . . The upper canine teeth, when in functional contact with the lower canines and first premolars determine both lateral and protrusive movements of the mandible . . . . The canine teeth also have a unique function. They are extremely sensitive organs. When their opponents come in contact during attempted eccentric movements of the mandible, they transmit in a greater degree than any other teeth the desirable periodontal proprioceptor impulses to the muscles of mastication, reducing muscular tension and thereby reducing the magnitude of applied force. This is the all important function we seek to reduce or prevent failure of restorations and the periodontium." There are some factors of this statement or theory that I think might be difficult to substantiate. At all times, when the prominence of the cuspid teeth precludes contact of all other teeth in eccentric positions, functional efficiency, comfort, and the most desirable or favorable distribution of functional force to the periodontium are negated. I am now informed that some former converts to this philosophy of oral rehabilitation are less staunch in their support of it because of the traumatic injury to the periodontium of the cuspids.

With the cuspid-protected occlusion as advocated, the cuspid teeth on the opposite side would take the stress from the posterior balancing inclines, and this most important factor of posterior tooth trauma would be relieved (Fig. 7). But why place all of this stress upon the cuspid teeth? If the lateral incline of the cuspid were in harmony with the working inclines of the posterior teeth, this stress would be distributed to many teeth rather than being carried by one. Why deprive the patient of lateral eccentric functional contacts on the working inclines of the posterior teeth essential for normal mastication and the more favorable distribution of this eccentric functional stress when by a reduction of the steepness of balancing inclines, as I have suggested, the most destructive trauma will be eliminated with little or no reduction of functional efficiency.

I wish to express my grateful appreciation to Dr. Lawrence Weinberg, Brooklyn, N. Y., for his able assistance in preparing the accompanying diagrams.

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AN ORAL REHABILITATION TECHNIQUE UTILIZING COPPER BAND IMPRESSIONS

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THE TECHNIQUE of using copper band impressions as transfer copings is valuable for immediate revelation of parallelism of preparations, for accurate transfer of copings, and for duplication of the prepared teeth. The procedure eliminates the error often encountered in the transfer of dies to distorted wax or plaster records and also eliminates the visit necessary for the try-in of metal transfer copings.

A three appointment, step by step procedure for a permanent complete mouth splint will be described.

FIRST APPOINTMENT

Complete alginate (irreversible hydrocolloid) impressions are made of both dental arches for a twofold purpose: (1) so that a duplicate temporary acrylic resin splint can be fabricated and (2) to secure diagnostic casts.

Lines are drawn on the patient's face and continued onto the tray with indelible pencil to facilitate the replacement of the impression for splint construction after the teeth are prepared (Fig. 1).

The abutments are prepared except for one or two posterior teeth that are in occlusion with the teeth of the opposite jaw (Fig. 2). The unprepared teeth aid in making jaw relation records.

Modeling compound impressions are made in copper bands, and after checking each one for accurate finishing lines and scraping off the excess modeling compound, the bands are reseated on the prepared abutments (Fig. 3). The bands are ligated in a continuous fashion with 24 gauge dead soft brass wire. The brass wire must contact the copper bands and not the modeling compound. Three inches of wire is extended freely beyond the last ligated copper band to make contact with the anode of the copper-plating instrument (Fig. 4).

A lubricated aluminum tray is filled with plaster, and a plaster index is made over all of the copper bands. The impression is cooled sufficiently to prevent distortion of the modeling compound impressions and removed (Fig. 5). A thin wax interocclusal centric relation record is made.

A temporary acrylic resin splint is then fabricated using the original irreversible hydrocolloid impression. The powder is placed into the impressions of the teeth, and liquid is added until the powder is saturated. The impression is reseated in the mouth using the few unprepared teeth and the indelible pencil marks (Fig. 1) as guides.

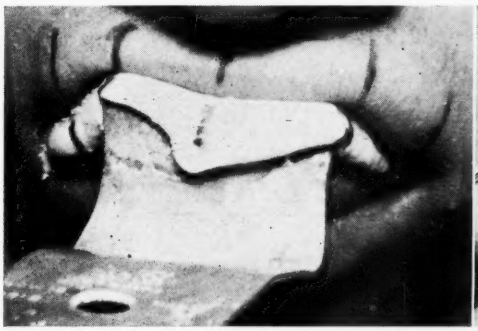

Fig. 1.

Fig. 2.

Fig. 1.—An irreversible hydrocolloid impression is in place in the mouth. The blue indelible pencil marks facilitate reinsertion of the impression for fabrication of a temporary acrylic resin splint after the teeth have been prepared.

Fig. 2.—The abutment teeth are prepared. Two molars are not prepared, since they are used to assist in making accurate jaw relation records.

Fig. 3.

Fig. 4.

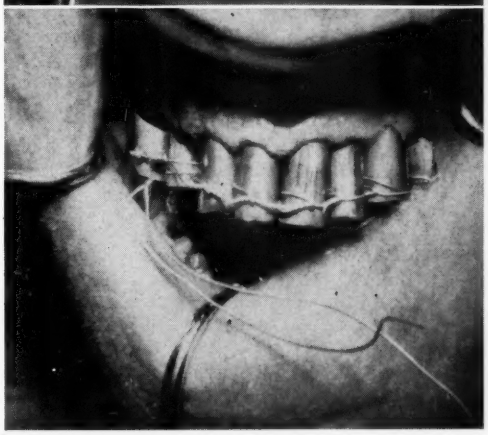

Fig. 3.—The copper band impressions are in position on the prepared teeth.

Fig. 4.—A piece of 24 gauge dead soft brass wire is ligated to the copper bands.

After the acrylic resin has cured, the impression is removed. The splint is trimmed and cemented in the mouth with zinc oxide–eugenol cement (Figs. 6 and 7). The splint should fit the gingival tissues properly and should duplicate the original teeth so closely that it can be used as a guide in making the interocclusal record after the remaining teeth have been prepared. However, when this procedure is difficult, the unprepared teeth on the second side are used as a guide to perfect the occlusion of the completed crowns on the first side. Then the completed crowns are used as a guide in making the interocclusal record for the prepared teeth on the second side.

LABORATORY PROCEDURES

The aluminum tray is separated from the plaster index containing the modeling compound band impressions. The terminal 3 inches of the brass wire is attached

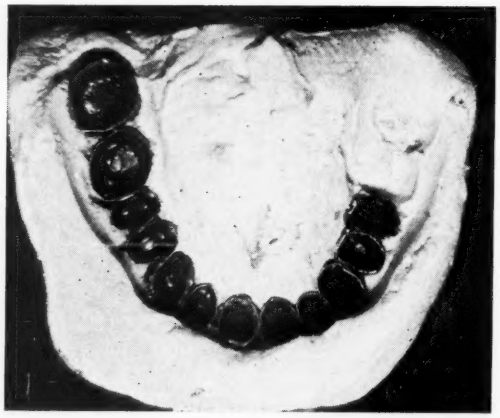

Fig. 5.—The copper band modeling compound impressions are in place in the plaster index.

to the anode of the copper-plating instrument, the entire mass is immersed in the solution, and the plating process is allowed to continue overnight. Only the copper band impressions will be plated (Fig. 8).

Dowel pins are the most desirable and adaptable for die attachments with this technique. The copper-plated modeling compound impression bands are filled with acrylic resin, and then the dowel pins are placed in the resin. No trimming of dies is necessary (Fig. 9).

An artificial stone counter cast is poured into the plaster index which contains the lubricated dowel pins. The stone cast is separated from the plaster index, and the copper-plated dies should be perfect duplicates and positioned exactly as the prepared teeth in the mouth (Fig. 10). The dies are waxed, and the castings are completed (Fig. 11). In most instances, the occlusal plane is re-established with the remaining natural teeth as a guide. Castings are not constructed at a level above the highest remaining natural tooth.

Fig. 6.

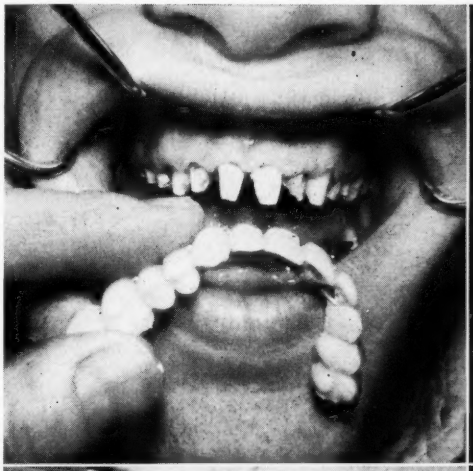

Fig. 9.

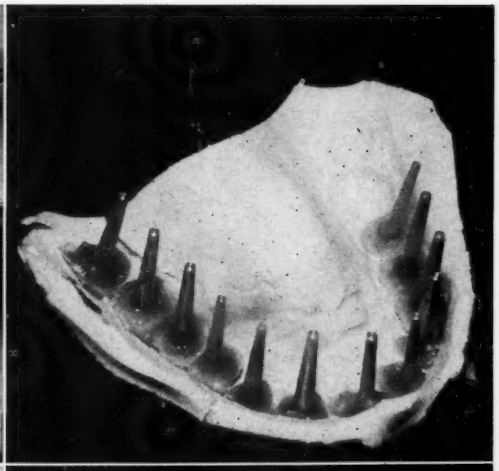

Fig. 7.

Fig. 10.

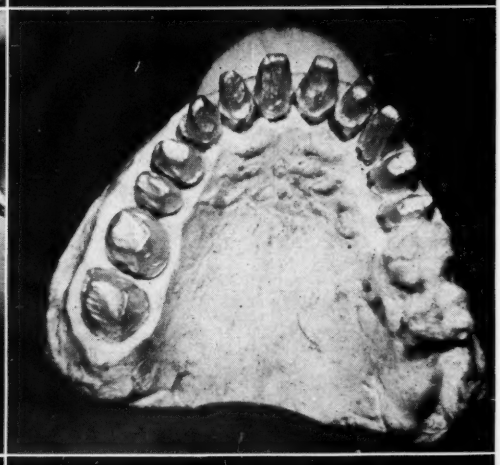

Fig. 8.

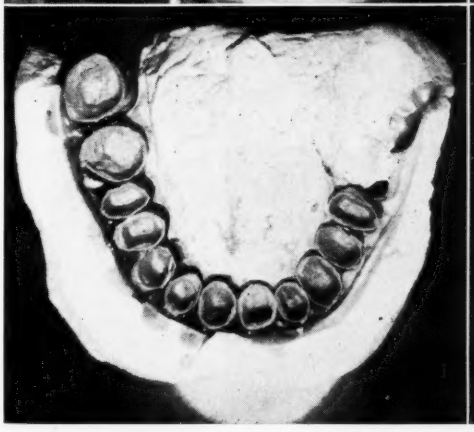

Fig. 11.

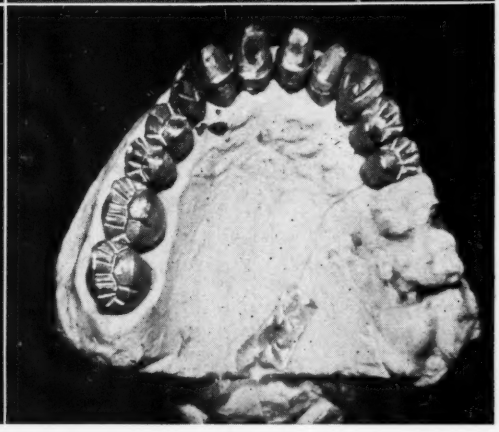

Fig. 6.—The acrylic resin splint is ready for temporary cementation in the mouth.
Fig. 7.—The acrylic resin splint is in place in the mouth.
Fig. 8.—The copper-plated modeling compound band impressions are in the plaster index.
Fig. 9.—Dowel pins are inserted into cold-curing acrylic resin, which is placed in the plated impressions of the prepared teeth.
Fig. 10.—The dies have the same relation to each other as the natural teeth.
Fig. 11.—The completed castings are on the artificial stone cast.

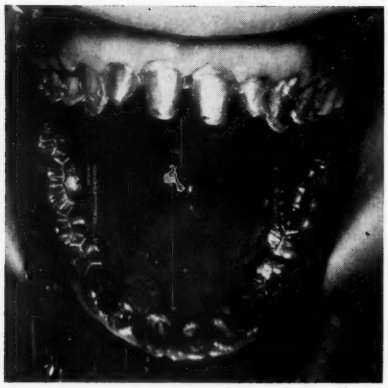

Fig. 12.—The abutment castings are in place in the mouth.

SECOND APPOINTMENT

The abutment castings are fitted on the prepared teeth (Fig. 12), and a thin, accurate interocclusal wax record is made and removed. A complete plaster index that includes the entire dental arch with the castings in place is made.

COMPLETING THE RESTORATION

The castings are soldered to one another, and pontics and facings are added wherever necessary (Fig. 13). The complete mouth splinted restoration is inserted on the third appointment (Fig. 14).

ADVANTAGES OF THE TECHNIQUE

The advantages of this technique are (1) elimination of complicated maxillo-mandibular registrations and complex articulators, (2) obviation of guesswork in seating dies in distorted wax records, (3) accurate interocclusal records, (4) fewer

Fig. 13.—The crowns are soldered together, and facings and pontics are added.

patient appointments, (5) accurate duplication of the prepared teeth, (6) immediate check on the parallelism of preparations, (7) good tissue retraction from the copper bands, (8) a minimum of patient discomfort, (9) elimination of receding gingivae around ill-fitting temporary fixed resin splints, (10) elimination of drifting of prepared teeth, and (11) occlusal reduction of high castings.

DISADVANTAGES OF THE TECHNIQUE

The disadvantages of this technique are (1) the need to cool the plaster index before its removal to prevent distortion of the modeling compound, (2) the possibility that the plaster index may break during separation if the inside of the aluminum tray is not lubricated, and (3) failure of the impressions to become copper plated if the brass wire does not contact the copper bands.

Fig. 14.—The completed restoration is in place in the mouth.

Two of the disadvantages are easily corrected. If the metal tray will not separate from the plaster index, the entire surface of the tray is covered with wax and the entire mass is placed in the plating solution. When some of the modeling compound impressions do not accept the copper plating, the plating index is removed from the solution and the plaster is carefully removed to expose the unplated copper bands. The brass wire is wrapped around these bands, the free end of the wire is attached to the anode, and the index is once again immersed in the plating solution.

CONCLUSIONS

Simple theories and uncomplicated methods are efficient and produce excellent results in complete mouth rehabilitation. The technique described is simple and permits accurate orientation of dies through the use of modeling compound copper band impressions.

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COMPLETE CROWN FORM AND THE PERIODONTIUM

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THE FUNDAMENTALS OF TOOTH FORM at the cervical third of crowns or of roots must be considered when making restorations of clinical crowns, because somewhere within those areas, the periodontal attachment will be located.

Physiologically, the tooth has two duties to perform. First, the tooth must assist in the processing of food for assimilation by the body. Second, the tooth, through its form, must help ensure its normal position by guarding against displacement. This displacement, if it should take place, cancels some phases of the usefulness of the tooth and may jeopardize the supporting tissues, with ultimate loss of the tooth. Naturally, the loss of one unit in the dental arch facilitates the loss of others and, in time, affects both dental arches adversely.

The clinical crown of a tooth (that part which is above the gingival line of surrounding gum tissue) depends entirely on its macroscopic form for proper function. The form must be properly correlated with other tooth crowns in both dental arches.

Physiology is a study of the function of the organs and parts during life, as distinct from anatomy, which deals with their structure. The teeth are peculiar biologically, in that their anatomic (macroscopic) and physiologic features are so closely merged that it is difficult to discuss anatomy without discussing function. Form and function are two expressions which imply one term when the clinical crown of the tooth is discussed. Therefore, dental anatomy and dental physiology must be treated as one subject.

The following hypothesis must be recognized and accepted by all students of tooth form. The maximum part of the tooth outline and tooth bulk or volume is intended for stabilization. This leaves the minimum part of the tooth for a working surface or actual occlusal contact with opposing teeth.

The primary purpose of the teeth is to incise and reduce food material during mastication. However, this function would be of limited duration if the tooth were unable to help sustain itself by assisting in the development and protection of the tissues that support it.

RESPONSIBILITY OF THE DENTIST

These facts emphasize the responsibility of the dentist when he removes most of the functional form of a clinical crown to prepare a tooth for a full crown.

Read before the American Academy of Crown and Bridge Prosthodontics in Chicago, Ill.

After the tooth is reduced to impotency, the dentist is obliged to restore it to its original usefulness without qualification. The restoration will require all the skill he can muster.

There can be no comparison between the skill required for partial restoration of a tooth crown, as for a filling or an inlay, and full restoration, as in full crown therapy. Complete crown preparations involve all of the functional form of the tooth. A good rule is not, at anytime, to *remove more normal tooth structure than is absolutely necessary for a satisfactory restoration.*

Preparation and restoration are interrelated. I have said to students many times, "If you are unable to carve the teeth 'up,' as you need to do in restoration, you have no moral right to carve them 'down,' as you need to do during preparation." This advice should be taken seriously by those who attempt occlusal equilibration.

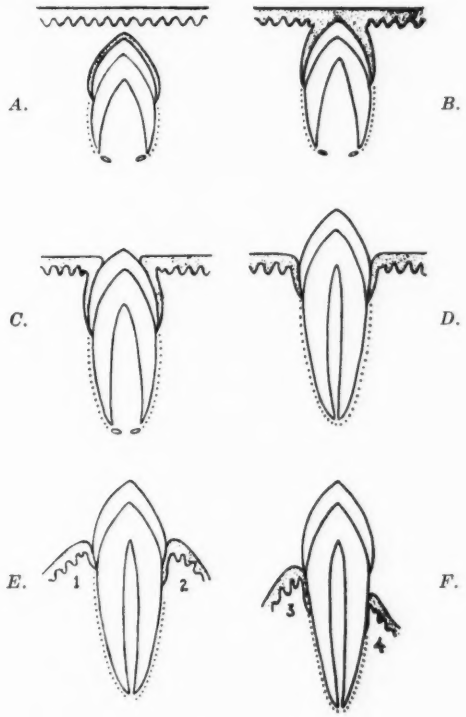


Fig 1.—*A,* The tooth germ is separate from the epithelium of the oral mucous membrane. The enamel is covered by the reduced enamel epithelium. *B,* The reduced enamel epithelium and the epithelium of the oral mucous membrane are united. *C,* The tip of the enamel has erupted through the epithelium, but there is no break in the continuity of the epithelium. No connective tissue is exposed. The epithelium, if attached, is joined to the enamel. *D,* The tooth has erupted into occlusion. The epithelium is still attached to the enamel. The apical end of the epithelial attachment is at the cementoenamel junction. *E* and *F,* The changing position of the dentogingival junction: *(1)* the bottom of the gingival sulcus is on the enamel, the apical end of the epithelial attachment at the cementoenamel junction; *(2)* the bottom of the sulcus is still on the enamel, but the apical end of the attachment has shifted to the cementum; *(3)* the bottom of the sulcus is at the cementoenamel junction; the apical end of the attachment has progressed apically; *(4)* the entire epithelial attachment shifts apically; the bottom of the sulcus is on the cementum and part of the root surface is exposed. (From Orban, B. J., and Coauthors: Periodontics, St. Louis, 1958, The C. V. Mosby Company.)

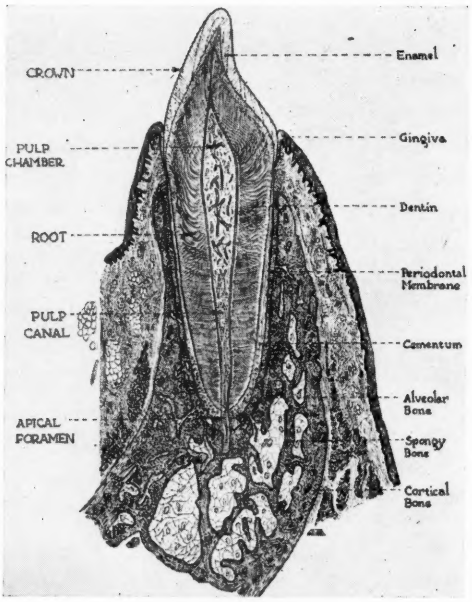


Fig. 2.—A diagrammatic representation of the dental tissues. (From Noyes, F. B., Schour, I., and Noyes, H. J.: Dental Histology and Embryology, ed. 5, Philadelphia, 1938, Lea & Febiger.)

REVIEW OF THE HISTOLOGY OF THE PERIODONTIUM EXPOSURE OF THE CLINICAL CROWN

The periodontal membrane attachment at the cementoenamel junction does not represent the bottom of the gingival crevice around tooth crowns. An epithelial band of attachment must be considered regardless of the gingival level on crowns or roots.

The epithelial attachment principle was established by Gottlieb[1] and has been elaborated upon by many histologists.[2-4] However, dentists must be reminded of this known truth, partly because dental education in operative dentistry has emphasized it only recently. Fixed partial denture techniques must be included as a subject requiring the same emphasis.

When the tissues surrounding a tooth are normal and healthy, the free margin of the gum is limited. Thus, a shallow gingival crevice is created (Fig. 1).

Orban[5] states, "The harmonious biologic functional independence of the periodontal tissue may be disturbed by various factors. These are broadly classified into those of extrinsic origin and those of intrinsic origin.

"The extrinsic factors are local irritants found in the gingival sulcus—mainly uncalcified and calcified dental deposits (calculus) as well as products of ever present organisms. Other irritants may include: *dental restorations not executed according to periodontal specifications. . . .*"

The dentist must carefully consider what is included by "periodontal specifications." His problems are: What is the functional form which the tooth presents; is it normal? Will the reduction of these teeth be conservative or radical?

How far can I go in preparation of this tissue, and what will I have to do to restore it to normal function or improve the function? Figs. 2 through 6 review the normal periodontal tissues.

The teeth possess certain fundamental curvatures which help give the proper degree of protection to the periodontium. Some protective curvatures are so finely drawn that any interference would seriously affect the future of the teeth. These protective curvatures are physiologic.

Research on the physiologic significance of tooth forms has been limited. However, certain fundamental outlines of individual teeth have functional significance which is important to them singly and collectively in improving or decreasing their efficiency. The term efficiency implies that each tooth must help ensure its own position, thereby doing its share toward the stability of the entire dental arch. The tooth does this through its biologic form in addition to its efficiency in the mechanics of mastication.

A normal tooth form with a healthy hermetically sealed periodontal tissue attachment creates a hygienic situation around itself and the adjacent teeth. This affords continuous protection without which the most perfectly formed tooth cannot last.

Some of the curvatures of the tooth protect soft tissues from frictional trauma and, paradoxically, may allow just the proper degree of frictional massage during

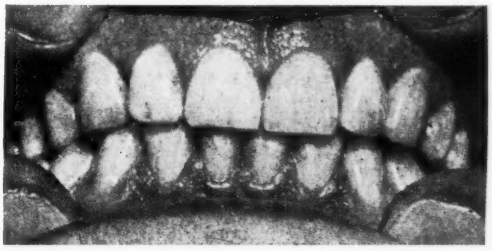


Fig. 3.—The interdental tissue of normal, healthy gums reaches well into the embrasures. (From Bunting, R. W.: A Textbook of Oral Pathology, Philadelphia, 1929, Lea & Febiger.)

mastication. Therefore, the conclusion is drawn that the tooth form provides protection or stimulation as needed and contributes, also, to hygienic conditions so necessary to its life.

Teeth are subject to abnormal development and anomalies of form as are other parts of the body. Undoubtedly, many teeth are lost prematurely because certain functional outlines fail to develop properly or because malalignment of those properly developed outlines made the protective contours inoperative. A good diagnosis and prognosis for subsequent dental treatment of any sort must take into consideration all that is known of physiologic tooth form, alignment, and occlusion.

The study of the protective functional form of the tooth crowns must include as minimum requirements: (1) proximal contact areas, (2) interproximal spacing,

(3) embrasures and escapement, (4) the occlusal thirds, (5) curvatures of the cervical line of the crown mesially and distally, which govern the height of the attachment interproximally (cementoenamel junction), and (6) labial and lingual curvatures (contours) at the cervical and middle thirds of crowns when the teeth are viewed from the mesial or distal aspect.

Only the last two requirements will be discussed in some detail.

CURVATURES OF THE CERVICAL LINE OF THE CROWN MESIALLY AND DISTALLY

Normal mesial and distal periodontal attachments copy the curvature of the cementoenamel junction. Therefore, a comparison of the cervical curvatures of extracted teeth is in order.

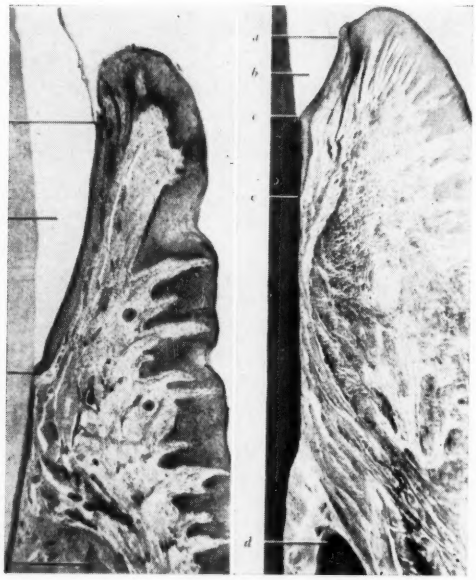


Fig. 4.—*A*, The epithelial attachment is on the enamel (first stage in passive tooth exposure). The apical end of the attachment is at the cementoenamel junction. *B*, The epithelial attachment is on the enamel and cementum (second stage in passive tooth exposure). The apical end of the attachment has proliferated along the cementum: *(a)* the bottom of the gingival sulcus; *(b)* the enamel; *(c)* the cementoenamel junction; *(d)* the alveolar crest; *(e)* the apical end of the epithelial attachment. (From Orban, B. J., and Coauthors: Periodontics, St. Louis, 1958, The C. V. Mosby Company.)

The extent of curvature of a tooth depends on the level of contact with the adjacent tooth above the crown cervix and also on the labiolingual or buccolingual diameter of the crown. The periodontal membrane is attached just about as high on mandibular as on maxillary teeth, although the mandibular anterior teeth average 1 mm. less in labiolingual diameter (except the lateral incisors). The contact levels are higher in comparison, being almost at the incisal edges. Consequently,

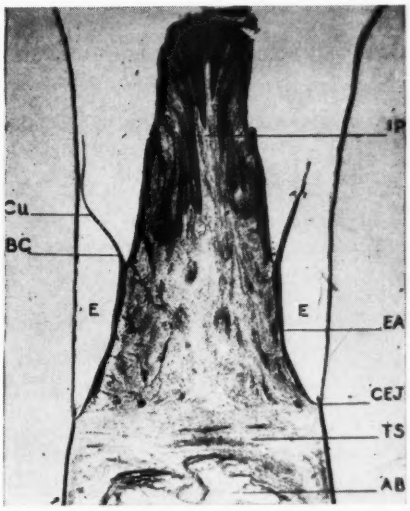


Fig. 5.—Interdental papilla and bone between two lower premolars of a child 14 years of age. The photomicrograph shows the topographic relation between the interdental papilla, the epithelial attachment to the enamel of both premolars, the transeptal fibers, the interdental bone, and the periodontal membrane: *(IP)* the interdental papilla; *(E)* the space formerly occupied by the enamel; *(EA)* the epithelial attachment to the enamel; *(CU)* the enamel cuticle; *(BC)* the bottom of the gingival crevice; *(CEJ)* the cementoenamel junction; *(TS)* the transeptal fibers; *(AB)* the alveolar bone. (×24.) (From Kronfeld, R.: Dental Histology and Comparative Dental Anatomy, Philadelphia, 1937, Lea & Febiger.)

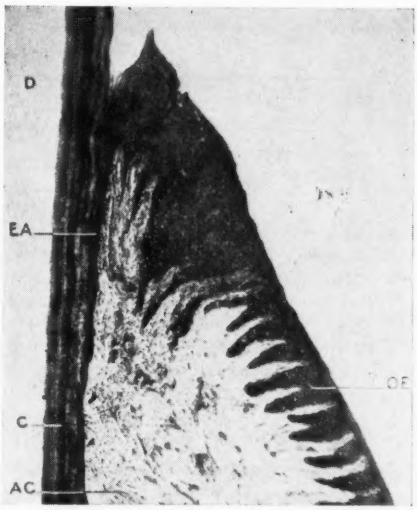


Fig. 6.—The epithelial attachment and gingival crevice of the lingual side of a lower bicuspid of a 52-year-old adult. The bottom of the gingival crevice is located on the root surface: *(D)* the dentin; *(C)* the cementum; *(EA)* the epithelial atachment to the cementum; *(OE)* the oral epithelium; *(AC)* the alveolar crest fibers. (×55.) (From Kronfeld, R.: Dental Histology and Comparative Dental Anatomy, Philadelphia, 1937, Lea & Febiger.)

calibrations show less than 1 mm. of variation between maxillary and mandibular teeth in the anterior region. Outline drawings of the teeth on one side of the dental arch as viewed labially and buccally are seen in Fig. 7.

The curvature of the cementoenamel junction is about 1 mm. less on the distal side than on the mesial side of the tooth. Therefore, if the upper central incisor measures 3.5 mm. of curvature on the mesial surface, the distal surface will have approximately 2.5 mm. of curvature. Greater or lesser curvatures are in proportion. A diagram of a central incisor of this size shows that the epithelial band of attachment parallels the curvature of the cementoenamel junction (Fig. 8).

The mesial side of central incisors, both maxillary and mandibular, exhibits the greatest curvature at the median line. The maxillary lateral incisor has a curvature on its mesial side about the same as that on the distal surface of the central incisor, if the lateral is in good proportion with the central incisor. The distal curvature is about 1 mm. less. The curvature depends on the size of the tooth which governs the dimension of the interproximal space between it and the adjacent tooth. The function of the periodontal attachment is to preserve the normal height of the gum contour, thereby maintaining the fullness of the interproximal space.

The crown form of the maxillary cuspid is that of an anterior tooth on the mesial half and a posterior tooth on its distal half, and, therefore, this tooth has curvatures accordingly. Since the contact area is higher on the mesial surface, the

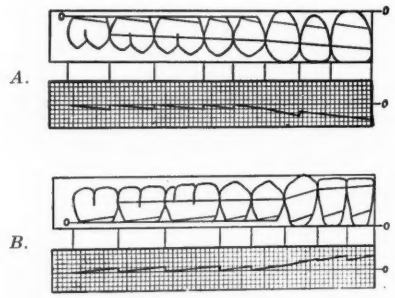


Fig 7.—Schematic drawings of the crowns of maxillary and mandibular teeth and associated graphs show the usual extent of curvatures of the cervical line mesially and distally. *A*, The maxillary teeth. *B*, The mandibular teeth. Compare the graph of cervical curvatures with a line drawn through the center of the contact areas. Note that the graph tends to run somewhat parallel to this line. (From Wheeler, R. C.: Dental Anatomy and Physiology, ed. 3, Philadelphia, 1958, W. B. Saunders Company.)

curvature is as great as that found on the mesial surface of the lateral incisor. Distally the contact of the maxillary cuspid is lower to correspond with the mesial aspect of the maxillary first premolar. Therefore, the distal attachment of the maxillary cuspid is lower also.

Premolars and molars are rather uniform in curvature. The contact levels are low in relation to total crown length, and these teeth do not have a high periodontal attachment. The average premolar or molar has a curvature of ap-

proximately 1 mm. on the mesial surface only and perhaps no curvature on the distal surface. If curvature is found on the mesial surface, the curvature will be no more than a fraction of a millimeter. Some molars have a negative curvature of a fraction of a millimeter on the distal surface, and the cementoenamel junction is almost straight across the mesial surface.

The mesial side of the mandibular central incisor often has a curvature as great as that of the maxillary central incisor, depending on the relative length of the crown and the type of tooth. The height of attachment on the average lower central incisor is probably 0.5 mm. less than that of the maxillary central incisor. The attachment on the distal surface is about 1 mm. less than that.

The mandibular lateral incisor has a crown that is as long as the mandibular central incisor or a trifle longer. Therefore, the interproximal design between these teeth also demands a high attachment on the mesial surface of the mandibular lateral incisor. The height of attachment is approximately the same both mesially and distally as that of the mandibular central incisor.

The mandibular canine is similar to the maxillary canine in form. The mesial and distal curvatures are also similar. Sometimes, mandibular canines have crowns that are much longer than the corresponding maxillary canines with higher contact points as a direct result. In these instances, the mesial and distal height of the periodontal attachment may be as much as 1 mm. greater.

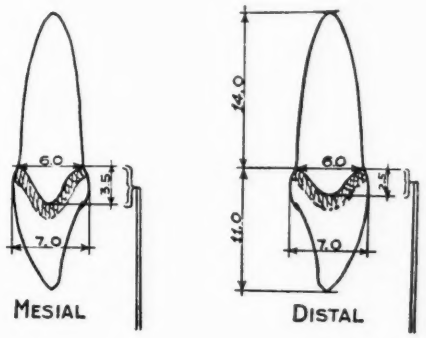


Fig. 8.—Mesial and distal curvatures of the cervical line (cementoenamel junction) on the maxillary central incisor demonstrate the points of measurement in determining the relation between the curvature of the cervical line mesially and distally. Other points of measurement of the crown and root are outlined. The shaded area in the form of a band on the enamel follows the curvature and represents the epithelial atachment of gingival tissue to the enamel of the crown. (From Wheeler, R. C.: Dental Anatomy and Physiology, ed. 3, Philadelphia, 1958, W. B. Saunders Company.)

Mandibular premolars and molars have cervical curvatures identical with maxillary posterior teeth and with the same slight variations.

A summary of the height of attachment, interproximally, indicates that the periodontal membrane attachments are at their highest points at the median line. In distal progression, the height of attachment decreases gradually to the mesial surface of the first premolar. Curvatures are slight from this point back through the third molars.

The possibility of injury of the mesial and distal attachments during crown preparation is indicated in Figs. 9 and 10. The mesial and distal height of epithelial attachments must be compared with the labial and lingual height during treatment to protect normal healthy tissue.

LABIAL AND LINGUAL CURVATURES AT CERVICAL AND MIDDLE THIRDS OF CROWNS

Tooth crowns have a fairly uniform labial and lingual curvature at the cervical thirds. These contours are usually called cervical ridges or cervical contours and have considerable physiologic importance. It is thought that the curvatures function by holding the gingivae under definite tension and also by protecting the soft tissues through their ability to deflect food material. The curvatures also may allow sufficient functional stimulation for necessary tissue massage. Whether or not these theories are true, the curvatures must be physiologic because they are so consistent and uniform. The curvatures are also that part of the enamel which has the epithelial attachment in youth and often even in later life.

Regardless of theories, the cervical ridges should remain intact or be carefully restored. The chances of accurate reproduction are so slight that the cervical ridges should be assailed with the greatest hesitancy, leaving them at least partially intact at every opportunity.

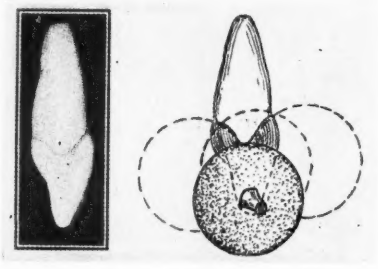


Fig. 9.

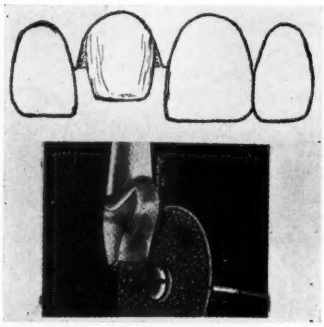


Fig. 10.

Figs. 9 and 10.—The possibility of injury of mesial and distal attachments is present during crown preparations. (From Wheeler, R. C.: Illinois D. J., vol. 15, 1946.)

Fig. 11, *C*, demonstrates the curvatures on a maxillary central incisor and canine. The extent of curvature above the cervical line is approximately 0.5 mm., and the cingulum of the canine has no greater curvature. The buccal and lingual curvatures of the maxillary first premolar and molar are seen in Fig. 11, *B*.

Mandibular posterior teeth tend to have a 0.5 mm. curvature buccally but have greater curvature lingually. The curvature is approximately centered on the lingual surface because of the relationship of the crown to the root (Fig. 11, *A*).

CLINICAL SIGNIFICANCE OF ATTACHMENTS AND CURVATURES

Crown preparations, of necessity, approach or include the cervical third of tooth crowns and, on occasion, the cervical third of the roots. The epithelial attachment of periodontal tissues is located somewhere in these areas. The function and future life of the restoration depend upon the preservation of the epithelial attachment and the normal form of the crown.

A good dentist has no difficulty in restoring the comparatively simple form of the middle and occlusal thirds of crowns. However, it is questionable whether any dentist can reproduce the cervical third of crowns or roots perfectly enough, and, certainly, he cannot restore it to a state of health if the periodontal attachment is injured in the process.

MARGIN EXTENT FOR FULL CROWNS

The extent of the margins for all types of crowns is important, particularly in cosmetic requirements and after periodontal surgical procedures which may expose the cervical third of the roots. There is no reason why the tooth form of anterior teeth cannot be changed to make the crown longer, thus placing the cervical margins further apically on the root. The single root form is simple and smooth and allows this adaptation (Fig. 12).

This technique is also permissible on most premolars. The form of the crowns must be continuous with the root form to preserve proper dental hygienic conditions without which the periodontal attachment will be assailed. For this reason, the cervical portion of the roots of some premolars and all molars must be left uncovered, even though exposed, because there is no way of replacing the natural form with any other that will function as well (Fig. 13). In addition, such a crown preparation is too close to the pulp if, for instance, the tapered preparation includes the root trunk of a molar.

Assuming good retention, the placement of the margin of full crowns depends entirely upon the tooth form and alignment. In the traditional approach to this question, crown margins are always placed "beneath the gum." However, in the biologic approach, the margins may be placed at any level that will perfect the form and preserve the periodontal attachment. The efforts should be directed toward *preservation* of the tooth and not toward a restoration that coincides with the expected in technical exhibits. Inlay margins are placed to suit the tooth, and no attempt is made to hide margins as such. The full crown, which is merely a more extended preparation, must be allowed the same privilege.

SUMMARY

The maximum portion of tooth outline and tooth volume is intended for stabilization of the tooth in the dental arch. This leaves the minimum portion for a working surface or actual contact with opposing teeth.

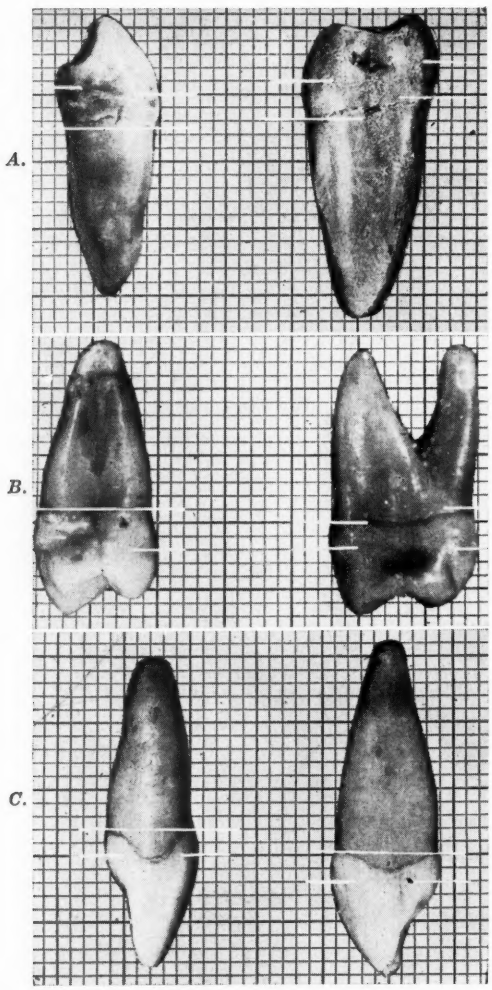
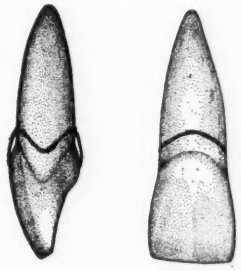


Fig. 11.—*A*, Maxillary central incisor and maxillary canine. *B*, Maxillary first premolar and maxillary first molar. *C*, Mandibular first premolar and mandibular first molar. White lines represent the levels of the cementoenamel junctions and the crests of contour of crowns when viewing the teeth from the mesial or distal aspect. The epithedial attachment is somewhere between these lines when it is on the enamel surfaces. These curvatures are protective, difficult to reproduce, and should be left intact whenever practicable.

Although the primary purpose of the tooth is to incise and reduce food material during mastication, this function would be of limited duration if the indi-

vidual tooth were unable to help sustain itself in the arch by assisting in the development and protection of the tissues that support it through its protective and functional form.

The location of crown margins should be decided upon by a logical approach to diagnosis and prognosis and not by taking a traditional design for granted. As-



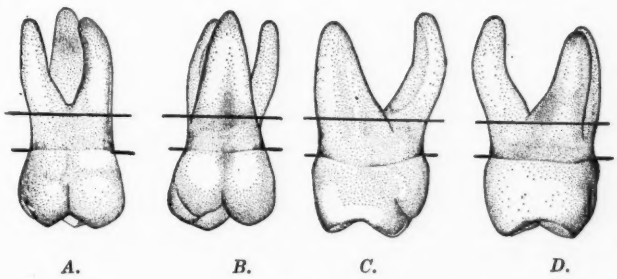
A. *B.*

Fig. 12.—*A*, The mesial aspect of the maxillary central incisor. *B*, The labial aspect of the tooth. The crown form may be extended on the root trunk of single-rooted teeth.

suming good retention and repair as necessary, the placement of the margin should depend mostly upon the tooth form and alignment and periodontal conditions.

In the traditional approach, crown margins are always placed beneath the gum. In the biologic approach, the margins are placed at any level which will best preserve the periodontium.

Complete crown restoration can be a radical procedure; therefore, extreme tooth reduction places a greater responsibility on the dentist for biologic reproduction by mechanical means.



A. *B.* *C.* *D.*

Fig. 13.—Various aspects of the maxillary first molar show the complicated form of the root trunk. *A*, Buccal. *B*, Lingual. *C*, Mesial. *D*, Distal. No attempt should be made to cover the root trunk, even though exposed in the restoration of molars, unless the encroachment of caries or erosion demands it. In that instance, the original root form must be reproduced to maintain proper dental hygiene.

In any situation, it is best to remove no more tooth form and structure than is necessary for satisfactory restoration.

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RUBBER-BASE IMPRESSIONS FOR FIXED PROSTHESIS

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THE PREPARATIONS OF TEETH for fixed partial dentures must be parallel. The unaided eye cannot be depended upon to assure parallelism of the preparations. Therefore, the prepared teeth must be surveyed by a mechanical paralleling device.

MAKING IMPRESSIONS

Retraction of Tissue.—The preparation and retraction of tissue for impression making were described in a previous article,[1] and the type of retraction to be used is indicated by the conditions presented by the patient. Some modifications must be made depending upon the type of restorations being used, e.g., gold and plastic, porcelain fused to a platinum alloy, etc. Minor undercuts need not be filled with cement, since they can be blocked out on the master dies with modeling compound.

Making a Paper Funnel.—A paper funnel[2,3] is formed to convey the mixed rubber-base impression material into the barrel of the syringe. A sheet from the 3 by 5 inch rubber-base mixing pad is folded in half. A second fold is made diagonally along the folded edge to create a tapered fold ¼ inch on one end and 1 inch on the other. A third fold is made by folding over the second fold. Then the paper is unfolded and a circle is made on the paper where the light-bodied syringe material is to be placed (Fig. 1).

Measuring Rubber-Base Impression Material.—Two mixing pads are used. One is the usual 3 by 5 inch size, and the other is 9 by 12 inches.

A 9 by 12 inch mixing pad may be obtained from a local printer. The specifications are that it be a one side-coated letterpress cover stock pad bound, on four sides except for one corner, with casein clear or colored bonding glue (lactate base).

All fixed partial dentures must be made with complete arch casts, so sufficient material must be prepared to make the necessary impressions.

Two inches of each of the light-bodied syringe materials is placed on a 3 by 5 inch mixing pad. Eighteen inches of each of the regular or heavy-bodied materials is placed on the coated side of a 9 by 12 inch mixing pad (Fig. 2).

Syringe and Tray Mixes.—The mixing spatula is coated on *one* side with the accelerator (brown) material. The base (white) tacky material is picked up with the *same* side of the spatula and incorporated thoroughly into the accelerator material. The base material will not adhere to the spatula because of the film of accelerator material on it. The mixing must be complete, with no streaking or marbling. The mixture is placed in the circle marked on the prepared paper, and

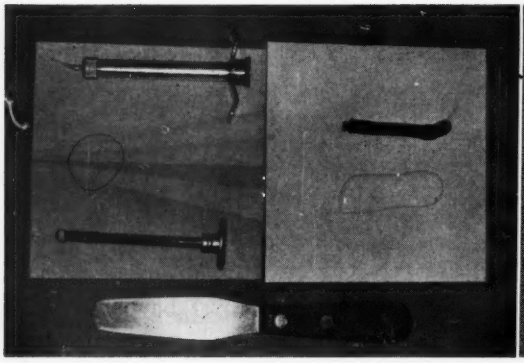

Fig. 1.

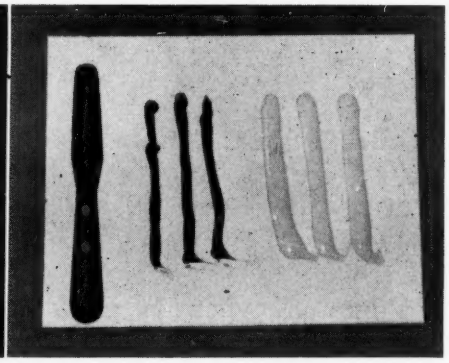

Fig. 2.

Fig. 1.—The syringe mix armamentarium includes a 3 by 5 inch mixing pad with rubber-base impression material, a syringe, a circled loading paper, and a modified Buffalo 10R spatula.

Fig. 2.—The tray mix armamentarium includes a 9 by 12 inch mixing pad with rubber-base impression material and a modified Buffalo 10R spatula.

the paper is refolded and rolled into a cone. The narrow end of the cone is placed in the loading end of the syringe, and the wide end of the cone is folded and squeezed to force the impression material into the syringe. The syringe is ready for use after the plunger is placed into position.

The large mix for a stock or preformed acrylic resin tray is prepared in the same manner. When a resin tray is used, it must be coated with two applications of the adhesive before the impression material is placed in it. The tray is loaded with the mixing spatula.

The retraction strands in the gingival sulcus are removed with serrated pliers.[1] The opened gingival sulcus around each preparation is completely filled with rubber-base impression material by carefully regulating movements of the syringe plunger so that the material will not be extruded too quickly. When the preparations are covered, the loaded tray is placed into position, thus uniting the two rubber-base materials. The material is allowed to cure in the mouth for 8 minutes. Then the tray is removed with a firm pull in the direction parallel to the long axes of the preparations.

The impression for the opposing cast may be made in an alginate material.

DIES

Making Dies and Reinforcing the Relationship Cast.—A small quantity of artificial stone* is mixed, and only that part of the impression that includes the abutment preparations is poured (Fig. 3). The impression is covered with a damp towel, and the stone is allowed to set for 1 hour. The cast is separated and cut into individual dies, which are later trimmed and used as the master dies.

Several paper clips are cut into different lengths and loops. The straight pieces of wire are attached with modeling compound to extend from the lingual to the

*Densite.

buccal surface of the impression over each abutment tooth and the tooth contacting it (Fig. 4). The loops of wire are placed into the abutment impression so that they extend to within 1 mm. of the deepest part of the impression. The loops are attached to the straight wires with modeling compound (Fig. 5). The impression is poured; when the stone has set, the wires reinforce the stone abutments. The complete arch cast is oriented with the cast of the opposite arch and mounted on an articulator.

The reinforced, mounted cast serves only to establish the occlusion, the contact areas, and the contour of the wax crowns and pontics. The cervical margins of the wax patterns are perfected on the master dies.

The impression material may tear at the gingival margins when the master dies are removed, and the second cast may require correction in these regions. Therefore, some of the artificial stone at the gingival margins of the preparations must be removed from the reinforced cast to make space for the wax crowns (Fig. 6).

Fig. 3. Fig. 4.

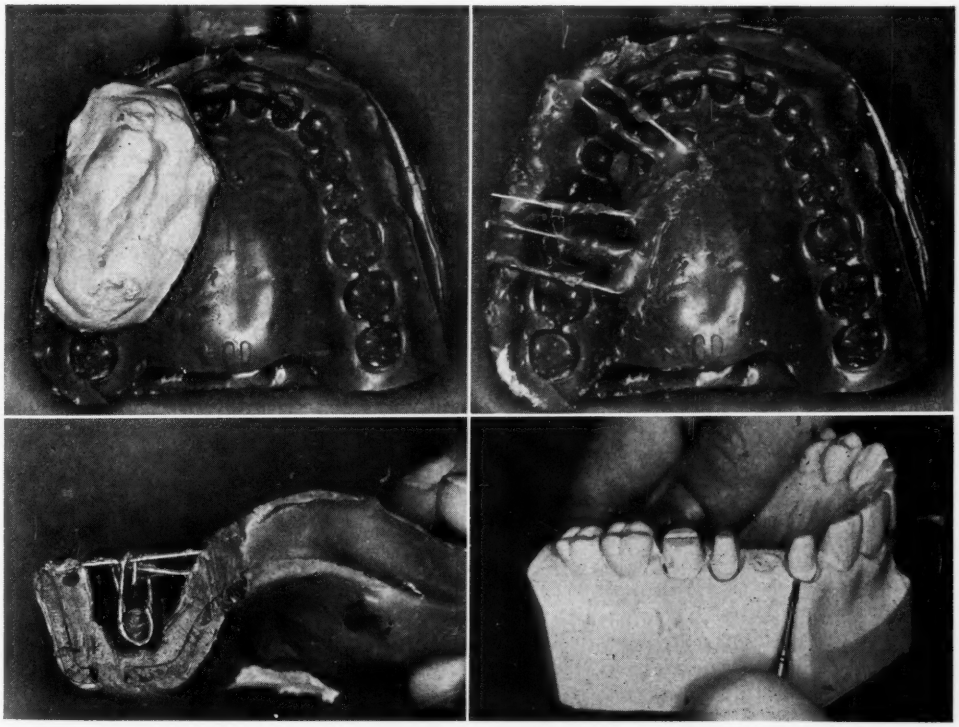

Fig. 5. Fig. 6.

Fig. 3.—A cast is poured in the area of abutments to make the master dies.

Fig. 4.—Reinforcement for the relationship cast is provided by wires attached to the impression with modeling compound.

Fig. 5.—A cross section view of the reinforcement for the relationship cast shows a wire loop suspended in the impression of the abutment tooth.

Fig. 6.—The gingival margins around the preparations are trimmed from the cast to allow clearance so that the wax patterns will seat perfectly.

Marking Dies for Positive Identification of the Cervical Margin.—The master die stem is carefully inked beyond the preparation margins, using a thin sable paint brush slightly moistened with steel blue.* The dark blue of the ink shows clearly so that an underextension or overextension of the wax pattern can be recognized easily (Fig. 7). Indistinct margins, such as those involving trifurcations or long distal slices, can be observed by seating the wax crown on the tooth in the mouth.

The completed castings are placed on the over-all reinforced cast, and they must seat perfectly on it. The pontics are waxed, cast, and connected to the abutment crowns. Occasionally, the metal framework is tried in the mouth, but in most instances, the porcelain or plastic facings are completed first.

IMPRESSIONS WHICH INCLUDE JAW RELATION RECORDS

A plastic unilateral anterior or posterior checkbite tray (Fig. 8) or a metal tray may be used to make an impression which includes an interocclusal record. The plastic tray must be coated with two coats of rubber-base adhesive. The plastic trays have the distinct advantage of being inexpensive, disposable, and less bulky. The metal trays are expensive, and the difficulty of removing the rubber material is time consuming and eventually will destroy the tray.

The same techniques are used for the preparation of the syringe and tray mixes, except that the tray is loaded on *both* the upper and lower sides. The loaded tray is placed into position, and the patient is instructed to close the teeth in centric relation. The closing may be observed on the opposite side of the mouth when the posterior checkbite tray is used (Fig. 9). After the impression material has set, the patient is instructed to open the mouth; the tray will remain on the quadrant containing the preparations. The impression is removed with an upward or downward thrust along the long axes of the preparations.

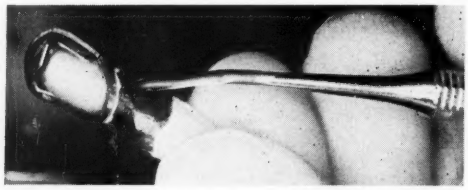

Fig. 7.—The inked area on the die defines the margins of the preparation so wax can be added to perfect the margins of the pattern.

The master dies are poured, the stone is allowed to set, and the dies are separated from the cast. Then the impression on each side of the tray is poured. The casts are mounted on the articulator before they are separated from the impression, and the previously outlined procedures are followed.

*Dykem.

IMPRESSION FOR A POST CROWN ON A PULPLESS TOOTH

Engine reamers* are used to prepare the canal after the coronal preparation.

The aperture of the plastic tip of the rubber-base syringe is too large to inject the rubber-base material into the postcanal of a pulpless tooth. Therefore, a tube† is cut and inserted into the back side of the plastic tip of the syringe by means of a large ball burnisher (Fig. 10). The tube is finger grasped and pulled forward until it becomes wedged against the plastic tip. Then the tube extension is cut to the desired opening. The flow of rubber-base material through the tip will hold the extension securely in position.

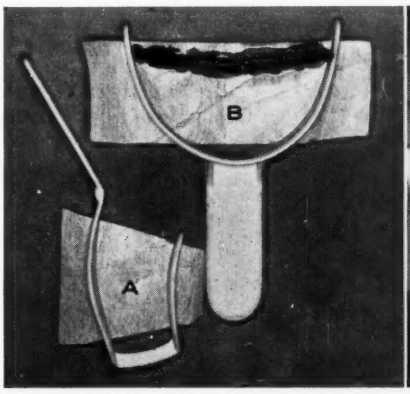

Fig. 8.

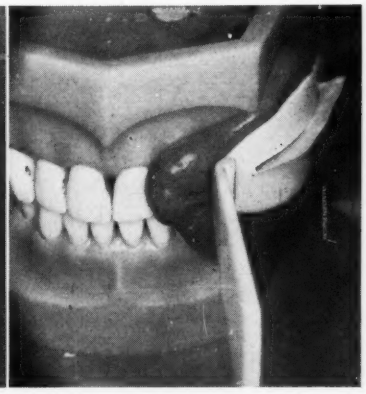

Fig. 9.

Fig. 8.—*(A)* A plastic unilateral posterior checkbite tray; *(B)* a plastic anterior checkbite tray with a wax strip added for a posterior dam. The trays have handles, lingual and labial or buccal flanges, and a separating Microcloth which divides the maxillary from the mandibular impression.

Fig. 9.—A plastic unilateral posterior checkbite tray is used to make impressions which include the interocclusal record.

A paper clip is cut at both ends, and one end is placed into the pulp canal so that it fits *loosely*. A loop is made on the end of the wire that extends out of the orifice of the canal. The loop must be formed so it will not interfere with the occlusion (Fig. 11). The wire is roughened with a disk, covered with a thin layer of rubber adhesive, and laid aside. The syringe tip is placed in the end of the prepared canal and slowly withdrawn as the rubber-base material is injected into the canal. Then the prepared and coated wire is dipped in the syringe mix of rubber-base material and placed into the filled canal. The impression material is injected into the gingival sulcus, and the entire preparation and the exposed wire loop are covered with rubber-base impression material. The wire loop reinforces the rubber-base material and binds the cone impression of the canal to the rest of the impression material. This prevents the impression of the canal from breaking off when the master die is separated. The remaining techinque follows the unilateral or the complete arch impression procedure.

*Peeso and Ottolengui.

†Cellutube.

Fig. 10.—Schematic drawings demonstrate the formation of the extension tip for the plastic syringe tip.

The tube extension is also of tremendous help in making impressions of preparations when the tissue is in good health and the epithelial attachment is excellent. The narrow orifice of the extension on the syringe tip minimizes tissue displacement. The tube extension may be curved by heating it over a flame and bending it.

IMPRESSION FOR A FULL OR VENEER CROWN UNDER AN EXISTING CLASP

The versatility of the rubber-base impression material makes the difficult procedure of constructing a crown under the clasp of an existing removable partial denture a simple procedure. However, one crown must be constructed at a time because the denture must be retained in its proper position by the other abutments. The impression is always made with the mouth closed in centric position so that the proper occlusal and cervical position of the denture will be maintained. Therefore, checkbite trays are necessary for the impression.

The preparation of the abutment tooth is made so that there is ample clearance between the clasp and the preparation for an adequate thickness of the crown. After the tissue retraction strands have been removed and with the denture out of the mouth, the syringe mix is injected around the abutment preparation. The removable partial denture is placed into position in the mouth, and the syringe mix injection is continued to cover all parts of the exposed clasp and occlusal

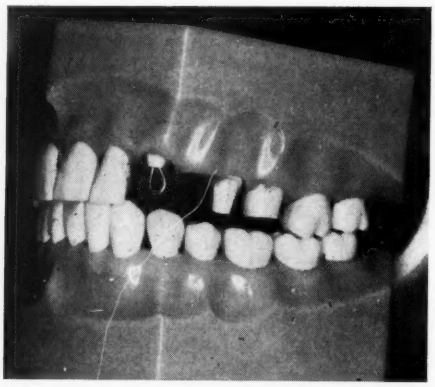

Fig. 11.—A wire loop made from a paper clip extends from the occlusal orifice of a pulp canal preparation.

rest (Fig. 12). Then the filled unilateral checkbite tray is placed into its predetermined position in the mouth, and the patient is instructed to close the teeth in centric relation. This closing is carefully observed on the side of the mouth opposite the impression. The denture is retained in the rubber-base material when the impression is removed from the mouth.

After the master die has been poured and separated, the abutment side of the impression is reinforced. All undercuts in the tissue surface of the denture base are eliminated before the relationship cast is poured on the side of the partial denture where the abutment is being prepared. The denture is removed only after the casts have been mounted on the articulator.

The wax pattern for the restoration is carved and placed on the prepared tooth in the mouth. The entire clasp and rest are lubricated with a light oil, and the partial denture is carefully seated in position. A heated ball burnisher is applied

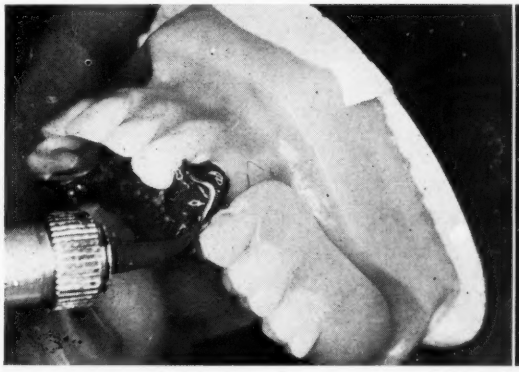

Fig. 12.

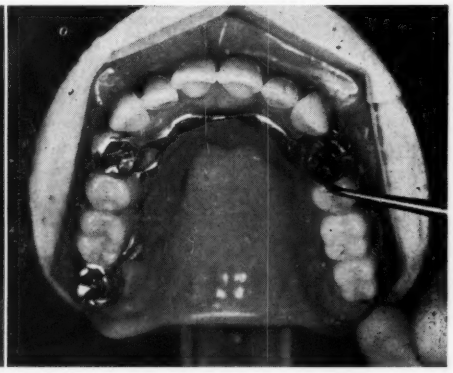

Fig. 13.

Fig. 12.—The rubber-base impression material is injected to cover all parts of the impression and the exposed clasp and rest.

Fig. 13.—A heated ball burnisher is applied to the occlusal rest of the removable partial denture to soften the wax pattern and shape the rest seat.

to the occlusal rest, and the patient is instructed to close the teeth in centric occlusion (Fig. 13). Any slight discrepancies in the occlusal rest preparation of the wax pattern for the crown may thus be corrected. The wax pattern is returned to the master die for adjustments of the margins following this heating procedure.

When the crown is finished, the clasp on the denture is lubricated and the crown is cemented into place with the partial denture in position. Lubrication prevents the cement from adhering to the clasp.

DISCUSSION

Two casts are poured in the same impression to simplify the procedure. The first cast provides the master dies, and all margins of the restorations are determined from them. The second, or relationship, cast serves as an accurate guide for the wax-up, contact with the adjacent teeth, occlusion, and contour. The castings

are seated on this reinforced cast for the construction of the pontics and assembly. Splints are made on it for investing and soldering. The final fit of the restoration is determined on this cast, and the veneers are completed on it. Therefore, the restoration can be completed with fewer appointments and with greater accuracy than by other methods.

Schnell and Phillips[4] state: "Pouring multiple dies from the same impression produces no greater distortion than merely storing the unpoured impression. The fact that successive dies show greater distortion probably is due to the effect of storage rather than the actual process of pouring and removing stored dies." Therefore, the dies and the relationship cast must be poured immediately and not just when convenient. Investigations of Schnell and Phillips[4,5] indicated that the use of the double mix procedure not only increases the initial accuracy but also reduces the distortion of the impression during storage.

The length of time the impression is allowed to cure in the mouth is critical. Phillips[5] insisted that the impression remain in the mouth for 8 minutes. Myers, Wepfer, and Peyton[6] advocated leaving the impressions in the mouth for 10 minutes from the start of the mixing. These recommendations are identical, since it takes approximately 2 minutes to mix the impression material for the syringe and get it into the tray and into the mouth.

One of the greatest controversies concerns the effect of thickness of the rubber-base impression material. Schnell and Phillips[4] showed that when a single mix is used in a band impression, the accuracy decreases as the thickness of the surrounding rubber-base material increases. In a double mix technique (syringe and tray material), the bulk of material is less critical.

CONCLUSION

Several techniques for the use of rubber-base impression material in fixed partial denture construction have been described. The advantages of these procedures are (1) accurate fit, (2) minimal occlusal adjustments, (3) precise contact areas, (4) more esthetic appearance, (5) fewer patient visits, and (6) more efficiency on the part of the dentist.

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FACTORS INFLUENCING SUCCESS OF PORCELAIN JACKET RESTORATIONS

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THE COMPLETE PORCELAIN VENEER CROWN restoration is a subject which invites the comprehensive approach. However, this article briefly reviews some of the clinical and technical aspects which have contributed to the successful use of this restoration.

ROENTGENOGRAPHIC DIAGNOSIS

The roentgenographic examination not only is a valuable aid in determining the maturity and health of the tooth but also enables the dentist to observe its subgingival profile. The form of the tooth is a significant factor in visualizing the finished preparation. If the tooth is very tapering, the preparation will lack good form for resistance unless the mesial and distal shoulders are kept narrow. Square and ovoid teeth permit less critical instrumentation in the management of proximal reductions.

JACKET CROWN PREPARATION

Efficient performance in the preparation for a porcelain jacket crown is approached from the same basic concept used in all clinical restorative dental procedures. The steps of preparation *must* be completed in an orderly manner. There has been little variation in the routine of preparation with the exception of improved rotary instruments and the use of high speed techniques. This discussion will be limited to the rotational speeds used, with emphasis on the preparation of the lingual shoulder.

A combination of slow and high rotational speeds is used in the preparation for a porcelain jacket crown. Deliberate and accurate proximal reductions are made with a 7/8 inch thin diamond disk rotating at 10,000 to 20,000 r.p.m. The labial and lingual proximal line angles are rounded with an inverted cone diamond point that cuts only on its face. This preliminary preparation using conventional instruments facilitates the high speed procedure and greatly reduces the possibility of a "phantom cut" on adjacent teeth.

The gross removal of the incisal and labial surfaces is accomplished with a 4 mm. thin wheel diamond instrument and a No. 701 carbide bur rotating at high

Read before the American Academy of Crown and Bridge Prosthodontics in Chicago, Ill.

speed. Many dentists routinely overcut the lingual shoulder by removal of the lingual enamel before the shoulder is completed. By reversing the order in this step of preparation, the lingual enamel is removed only at the level of the gingival crest. The remaining enamel of the cingulum resists the cutting instrument and aids in preventing the extension of the shoulder in an axial direction. Thus, the shoulder is completed to the desired depth and uniform width. Then, the remaining enamel on the lingual surface is removed. The preparation is finished with rotary instruments and sandpaper disks at standard speed and with hand instruments.

PREPARATION DEFICIENCIES

The lack of natural tooth structure to develop adequate resistance and retentive form can be the most disastrous. Porcelain must be supported by dentin or gold castings if it is subjected to force. A short incisogingival preparation must be lengthened so that the force resisted by the crown in the protrusive position can be absorbed by the supporting structure in a perpendicular direction. This precaution will alleviate the characteristic crescent-shaped fracture of the labial and sometimes the lingual surface of crowns.

The preparation which is extremely cone shaped, because of abnormal loss of tooth structure, must be restored to the proper mesiodistal width for maximal marginal ridge support of the crown. This correction helps prevent the vertical fracture of crowns caused by the torsional stress induced in the crown by the forces of mastication.

FRACTURED TOOTH SEGMENTS RETAINED BY PERIODONTAL ATTACHMENT

This procedure offers many advantages in the treatment of severely fractured teeth with pulpal involvement when a large fractured segment is retained by the periodontal attachment. Root canal therapy is performed as soon as possible, the total endodontic procedure being completed in one appointment.

Since the apical one-third of the root canal is filled permanently with gutta-percha or a silver point, the pulp cavity can be used for dowel retention of a temporary restoration. The construction of this restoration may follow the root canal

Fig. 1.—A split mold duplication of a tooth fragment in self-curing plastic.

Fig. 2.—The duplicated fragment is attached to a dowel, and the labial contour is completed and cemented in position.

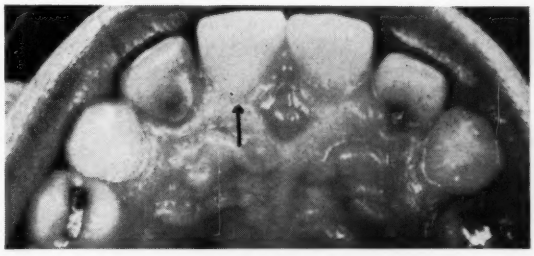

Fig. 3.—A temporary restoration of the lingual surface of the tooth maintaining the original tissue-tooth relation.

treatment at the same appointment or as soon as is practical. The fractured segment is removed and duplicated in self-curing acrylic resin by a split mold technique. A base metal dowel is fitted into the root canal. The duplicate plastic fragment is adjusted to the dowel and placed in accurate position against the fractured surface of the natural tooth. The plastic fragment is attached to the dowel with self-curing acrylic resin using the paint-on method. The jagged margins of the tooth are eliminated with a disk or diamond instrument, and the discrepancies are corrected by the addition of plastic.

The completed dowel-retained restoration is finished, polished, and cemented into place with a zinc oxide–eugenol cement. This temporary immediate restoration maintains the proper relation of the gingival tissues to the tooth during the period of healing, prevents the formation of granulation tissue over the fractured surface, produces a satisfactory esthetic effect, and assures the psychologic welfare and physical comfort of the patient (Figs. 1 through 6).

After the need for this intermediate treatment has passed, a permanent dowel-retained or dowel-supported porcelain restoration is constructed. The restorative procedures are facilitated because the margins of the fractured surface of the root are visible since it is not covered by hyperplastic tissue.

IRREGULARLY POSITIONED TEETH

Simple orthodontic movement is used to create more favorable conditions for treatment of teeth irregularly positioned with respect to the width of the space. This

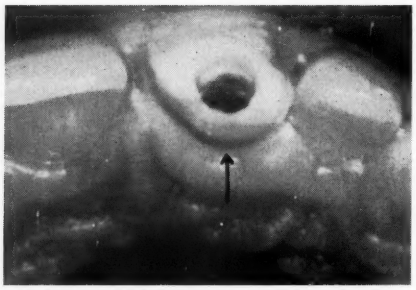

Fig. 4.—The gingival tissues have healed to the contour of the fractured margin of the root.

approach is frequently required in restoring peg-shaped lateral incisors, with diastemas, and in dental arches when an anterior tooth has been prematurely lost. Occasionally, it is necessary to reposition a tooth displaced by an injury before constructing the porcelain jacket crown. This procedure is applicable to both vital teeth and healthy pulpless teeth.

PROBLEM OF COLOR

The difference in the physical action or reaction of light on natural tooth structure as compared with porcelain is a problem in dentistry yet to be solved. However, each dentist develops individual skill in blending porcelain and duplicating color effects which are difficult to attain. The use of opaque, transparent, and improved standard porcelains has greatly increased the range of natural color effects. Opaque overlaid with standard or transparent incorporated with standard porcelain produces a more lifelike appearance by causing the light rays to pass through the transparent particles to be absorbed, reflected, and refracted by the underlying opacities. To duplicate the incisal color in natural teeth, the incisal translucencies require the addition of blue and gray stains to modified transparent porcelain. However, the color varies as the quality of light is altered. A porcelain jacket crown will not appear the same color for any length of time, because natural or artificial light changes.

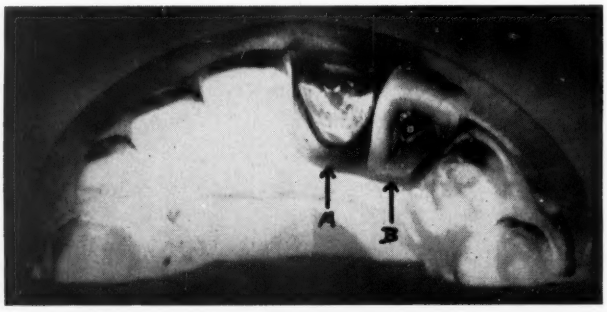

Fig. 5.—The final restoration may be retained by a fixed dowel or a cast core: *(A)* the die of the preparation with a fixed dowel compared to *(B)* the fractured surface of the original fragment.

DUPLICATION OF FORM

In view of the problem of color, the means which allows the dentist to achieve esthetic harmony of anterior crown restoration is the accurate duplication of form. Many dentists stress the need for an unusual artistic sense and contend that imagination is a prerequisite to achieve this extremely important requirement. This concept has caused many capable dentists not to try to develop proficiency in this aspect of dental service. These qualities may have been overemphasized.

Many fundamental facts aid in developing accurate contours of tooth form. Of these, the most important is probably the correct way to view the tooth. The true contour of the surface of a tooth is difficult to see unless the line of vision is parallel with the incisogingival plane of the labial surface. The exact position and

Fig. 6.—A pattern for a cast core showing excessive involvement of the lingual portion of crown and root.

alignment of the marginal ridges and developmental grooves are more distinct from this angle. The surface irregularities and striations become clear as the labial surface is rotated to a perpendicular position and turned from right to left. An understanding of the value of convex and flat surfaces in altering the appearance of length and width is necessary. The width and length of a crown appear to be less when the labial surface is convex mesiodistally and incisogingivally. Conversely, a flat surface appears to increase width and length. This principle has similar application in pontic construction for fixed partial dentures.

SURFACE HIGHLIGHTS

It is not enough to accurately duplicate the form and gross surface irregularities of the tooth. Attention must be given to the reproduction of detailed characteristics, including the proper degree of surface luster. These qualities are responsible to a great extent for the natural effect of surface highlights. The application of a wash coat of ground porcelain to the surface of a porcelain jacket crown in preparation for the glaze firing provides the facility for characterizing the surface. The gingival color of porcelain is ground in a mortar with a pestle, using excess water. It is then brushed on the surface, vibrated, and permitted to air dry for a short time. The surface markings are accentuated with a No. 1 sable brush. After glazing, the crown exhibits a very natural appearance.

CROWN CEMENTATION

The factors associated with cementation are the relationship of the crown, preparation and approximation of teeth, selection of the color of cement, toilet of the preparation, manipulation of cement, and placement of the crown. The removal of the glaze from the inner surface of the crown with a carborundum point may be the only adjustment necessary to fit the crown accurately on the preparation. This etching of the inner surface is desirable for greater mechanical retention of the cement. Diamond abrasive instruments or hand chisels are used to correct the preparation. The contact areas are corrected when necessary, and the glaze is always removed from the incisal edge to simulate a worn appearance. The surfaces void of glaze are polished with 120 mesh silex, using a rag wheel on the lathe.

The selection of the color of the cementing medium is influenced by clinical judgment in the use of siliceous and plastic cements. However, zinc phosphate cement powder mixed with water is a testing aid in selecting this type of cement.

The cleansing and isolation of the prepared tooth are completed, and a wick of twisted cotton or a piece of Gingipak is adapted to the shoulder in the gingival crevice. The inner surface of the crown is coated with a thick film of a proper mix of cement, and the crown is seated into place with a vibrating motion and held under finger pressure.

OCCLUSAL CORRECTIONS

Occlusion is of paramount importance in any restorative service. All interferences must be eliminated to provide a harmonious balance in the various contact relationships of masticatory function. The lingual surface in particular of upper anterior crowns should be contoured to permit mandibular protrusive excursions. The continued service of a porcelain restoration is enhanced by periodic checking and correction of occlusal imbalances.

SUMMARY

The factors that influence the success of porcelain jacket restorations have been discussed. Some of these factors are roentgenographic examinations, proper preparation of the tooth, harmony of color, duplication of form, and proper occlusion.

Methods of treating retained fractured tooth segments and irregularly positioned teeth and the development of surface highlights were described.

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INVISIBLE GOLD RESTORATIONS FOR ANTERIOR TEETH

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MANY DENTAL MATERIALS are available for the restoration of anterior teeth, but none are free from certain disadvantages. Silicate cements,[1] self-curing acrylic resins, and gold are used.[2] Of these, gold in all its forms has given the best results, but its appearance is objectionable.

The purpose of this article is to present a simple, practical, and conservative indirect technique for making cast gold restorations for anterior teeth without showing gold.

VERSATILITY OF THE GOLD INLAY

The gold inlay[3] has a solid place in modern dentistry. It provides an excellent cavity seal and excellent edge strength, and it will withstand all the normal stresses of mastication. It can reproduce the natural anatomic conditions and function and will *not discolor* the restored tooth. Highly polished before cementation, it tends to maintain good mouth hygiene, and its contact area with the adjacent tooth withstands wear and time.

Since all operative procedures discussed in this article are done by the lingual approach and because of the arched arrangement of the anterior teeth, the single impression technique must be used.

CLASS III PREPARATIONS

Before starting any operative procedure, the careful study of a roentgenogram is a good precaution against accidental pulp exposure. Except for certain modifications, the over-all procedures of this technique follow the generally recognized operative principles (Fig. 1). For efficiency, an orderly sequence in the various steps of preparations is used.

Read before the Prosthetic Staff of Tufts University, School of Dental Medicine, and the Tufts University Alumni Association, Boston, Mass.

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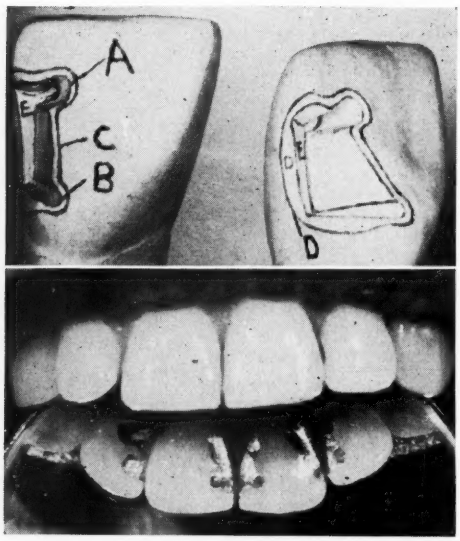
A.



B.

Fig. 1.—*A*, A class III preparation: *(A)* the incisal groove; the distal angle is left with adequate dentinoenamel support; *(B)* the gingival groove; *A* and *B* form a wide dovetail lock; *(E)* the labioaxial wall of the box; enough thickness should be left between *E* and the labial surface, otherwise a discolored patch will appear; *(C)* the bevel; *(D)* the slice and finish line. *B*, Four incisors with class III restorations. Note that no gold shows.

The decay is removed, and any pulp involvement or pulp protection should be taken care of first; then the cavity is filled with cement. For a tooth with incipient caries, the removal of decay is left to the very end of the procedure, just before cementing the inlay. If the decay is extensive and leaves the *labial enamel* unsupported by dentin, the weakened and translucent enamel is backed by an approximately 1 mm. layer of a well-matched silicate cement, after which the remainder of the cavity is filled immediately with oxyphosphate of zinc cement. This procedure is safe, since the weakened enamel (except that in the incisal third of the tooth) is not subjected to significant stresses of mastication. Unless this is done, an opaque spot may show through the enamel after the inlay is seated. If the labial surface has a notch, it should be restored with cement and, for the time being, considered as part of the labial surface of the tooth.

Separation.—Separation (Fig. 2) is necessary in order to prepare for the next step—the slicing. This will allow the separating disk to work freely in the interdental space and permit the unhindered passage of the impression tray between the teeth. If a tooth to be prepared overlaps the adjacent one labially, the maximum separation possible may be needed for ease of working. This separation should be obtained by the slow method (see Fig. 10). The separation should be maintained between sittings for convenience of placing, fitting, and cementing the inlay. After the cementation of the inlay, the tooth will move back to its original position.

Outline Form, Slicing, and Extension for Prevention.—The labial outline form should be determined before making the proximal cut or slice. It is marked at the embrasure with a pointed wax pencil following the labioproximal curvature of the adjacent tooth. In order that the inlay will not be visible, the slice should stop about 1 mm. short of that line.

The slice is made with a thin, flexible, safe-sided, medium grit lightening disk (Fig. 3). The cut is made at the expense of the proximal and lingual surfaces. (A diamond disk should *not* be used because it is too thick and rigid and cuts too fast and too much.) The safe side of the lightning disk is lubricated with petroleum jelly and held pressed against the adjacent tooth. The disk is *flexed* in such a way as to follow the predetermined labial outline form and stop cutting 1 mm. short of the line drawn on the tooth. The disk should rotate at moderate speed to avoid cutting too much. It should be stopped frequently to check the extent of the cut.

If decay reaches the gum line, the gingival outline should be carried 1 mm. below the free gum margin. This is done from the lingual surface, preferably with a tapered No. 700 diamond point held parallel to the slice.

Resistance Form.—The class III inlay is not subjected to much of the force of mastication, so the lingual box should not be more than about 1 mm. wide (Fig. 1, *E*). If the inlay is to be used as an abutment, the lingual box should be more pronounced to provide increased resistance and stability and to accommodate a lug rest.

Retentive Form.—Two grooves are formed to provide retentive form. The incisal groove is placed at the junction of the incisal and the middle thirds of the tooth (Fig. 1, *B*). The gingival groove is placed at the junction of the line angle formed by the gingival floor of the box and the axiopulpal wall (Fig. 1, *B*).

The incisal groove is made with a No. 701 carbide bur and should be about 2 mm. deep. Care is taken to avoid carrying this groove too deeply, because it might show through the translucent labial enamel wall.

The gingival groove can be made about 4 mm. deep. *The depth of both grooves* depends upon the labiolingual diameter of the tooth and the extent of the

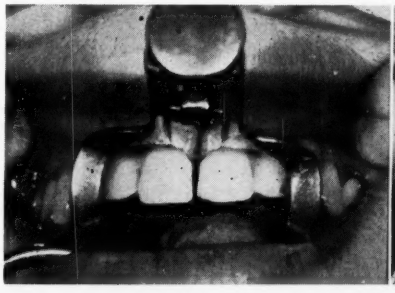


Fig. 2.

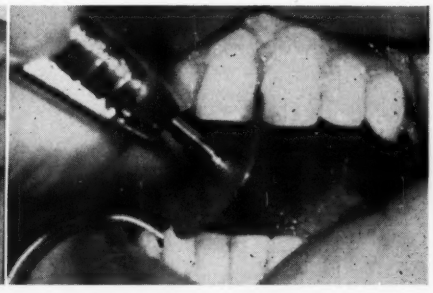


Fig. 3.

Fig. 2.—Although quick separation is often adequate, slow separation is preferable (see Fig. 10).

Fig. 3.—The slicing technique. The lightning disk is held flexed to protect the proximal incisal third of the tooth.

caries. Both grooves are made from the lingual surface of the tooth, holding the bur perpendicularly to the long axis of the tooth. They should be parallel so that together they form solid, locklike retention for the inlay.

Checking the Preparation.—It is difficult to make out the details and depth of these preparations because the anterior teeth are subjected to light from their labial aspect. Frequent stopping and checking are necessary to prevent undue cutting on the tooth. To test the preparation, the pointed tip of a piece of black boxing wax is warmed slightly and pressed into the cavity preparation. After chilling, the wax is withdrawn and examined with a magnifying lens. Any alterations which may be required will be apparent in the black wax.

Beveling.—The lingual margins are beveled as for other types of inlays. The labial and gingival margins are not beveled since they end in a fine edge finish line produced by the slice made on the proximal surface.

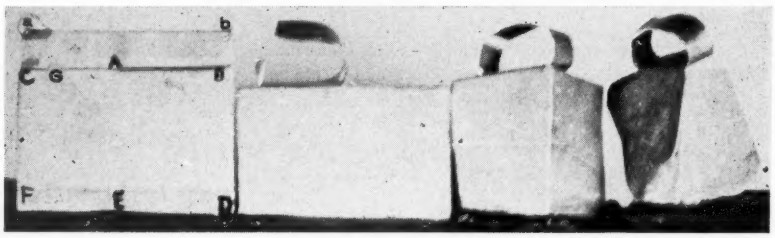


Fig. 4.—The steps in making an impression tray for a class III or IV impression.

Interocclusal Records.—It is not necessary to make a wax interocclusal record for a class III preparation. The pattern for the missing lingual part of the tooth is to be waxed flush with the remaining part of the lingual surface and contoured to form the proximal surface of the tooth.

Tray.—The impression is made by the indirect technique. A special tray is made from a sheet of brass 0.008 inch thick.

A rectangular piece of this metal 1.5 by 2 cm. is cut (Fig. 4) and bent to form the tray. The size can be varied according to the size of the tooth. Two cuts are made in the brass strip with a straight scissors (Fig. 4). Cut *AB* is longer than cut *CG*. The narrow strip *abBC* is then bent down at a right angle to the remaining plate to form the incisal stop for the tray. The free ends of the narrow strip are then bent upward to form the handle of the tray. The wider strip *(ABDE)* is bent backward to become the lateral wall of the tray, and the remainder *(CAEF)* forms the lingual wall of the tray. The tray is then fitted to the tooth and trimmed so that when the incisal stop rests on the incisal edge of the prepared tooth, the edges of the tray extend 2 mm. beyond the labial surface and about 1 mm. below the gingival finishing line. The tray must fit the tooth so that it follows the contour of the lingual surface and the proximal slice as closely as possible (Fig. 5). If the pattern is reversed, it will serve for the opposite side of the tooth. These trays may be prepared in advance in different sizes. Then, the right size may

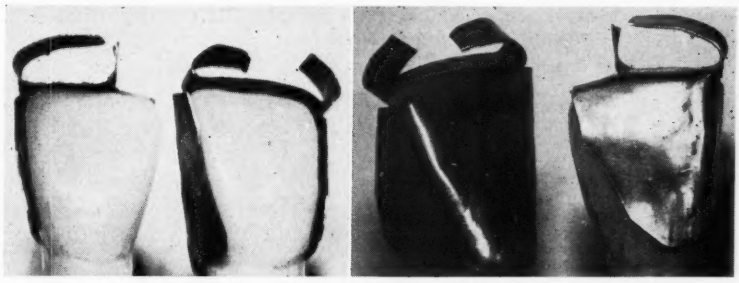
be chosen for the tooth being restored. The inside of each tray is roughened with a small inverted-cone bur to provide retention for the impression material.

Impression.—A fast-setting rubber-base impression material is used for the impression. It is very sensitive to room temperature and humidity, and constant 70° F. is recommended.[4,6] Manufacturer's instructions should be closely followed.

Before making the impressions, any gingival bleeding should be stopped and the tooth should be dried.

The impression material should not be mixed by the assistant because it is important that no air be incorporated into the mix. The experience and judgment of the dentist will avoid this difficulty. Mixing is done on a cool 1 inch thick glass slab with a stiff half round spatula held flat on the slab. Mixing is continued until the color is even. A tube* is then filled with the impression material, and its nozzle is inserted to the full depth of the grooves. Only the grooves are filled. In the meantime, the assistant fills the impression tray and hands it to the dentist, who pushes the tray gently but firmly into position on the tooth.

The elapsed time from the start of the mixing to the placement of the tray on the tooth should be about 1 minute. The impression is held immobile on the tooth for 2 minutes. Then, with a sharp and pointed scalpel, the excess impression material is gently cut off of the labial protruding end of the tray (Fig. 6). This cut follows the contour of the labial surface. Also, the material under the incisal stop is cut away, leaving 0.5 mm. of it in this region. A definite finish line shows when the impression is withdrawn lingually in line with the preparation.



A. *B.*

Fig. 5.—Fitting of the impression trays for class III or three-quarter crown restorations. *A*, Labial view. *B*, Lingual view.

The impression should be examined carefully with a magnifying lens. If satisfactory, the impression is washed with a mixture of equal parts of hydrogen peroxide and denatured alcohol, dried, and placed in a protecting box until it is electroplated.[5]

To prepare the impression for electroplating, one end of the 28 gauge copper lead wire is wrapped around the handle of the tray to make contact with it. Then the contact between the wire and the tray and any exposed tray metal is insu-

*Jiffy-tube.

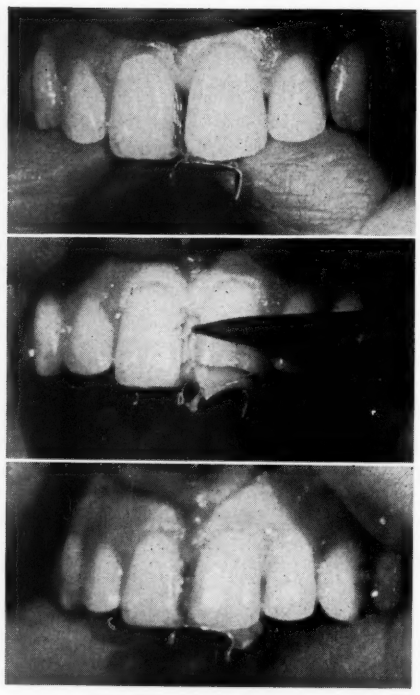


Fig. 6.—An impression for a class III restoration. *A*, Fitting the tray. *B*, Cutting away the excess impression material and freeing the labial surface. *C*, Sufficient material (0.5 mm.) is retained in order to preserve a well-defined labial finish line in the impression.

lated with 30 gauge wax. This wax should extend 2 mm. beyond the edges of the impression. The metalizing and plating procedures are carried out in the usual manner.

After being cast, the inlay is checked to determine the accuracy of its fit and to make certain that no gold is exposed on the labial surface of the tooth. The proximal surface of the inlay is shaped in such a way to reflect light toward the lingual surface. Thus, only the razor sharp labial edge of the inlay will be at the embrasure and will not be noticed (Fig. 7).

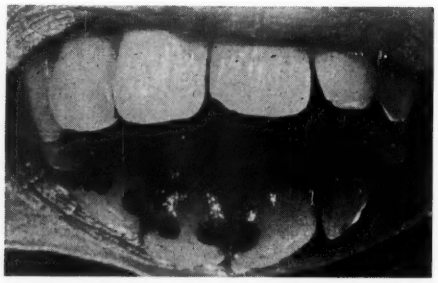


Fig. 7.—Completed class III restorations.

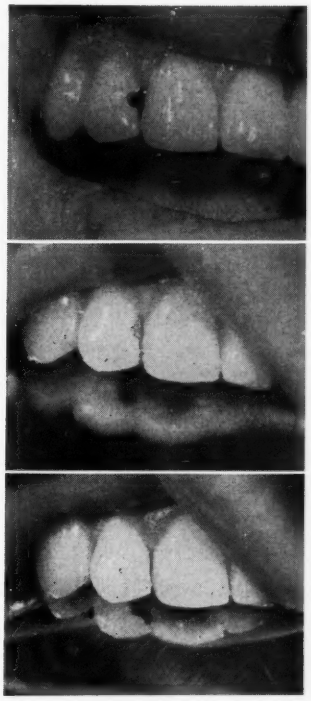


Fig. 8.—A class III restoration. *A*, The condition before the preparation was made. *B*, After cementing the restoration, the gold is masked with cement. *C*, Silicate cement completes the restoration.

If there is a notch in the labial surface of the tooth (Fig. 8), the gold should be cut back toward the embrasure so it cannot be seen from either side. The base of the gold box is masked with cement before the restoration is completed with silicate cement (Fig. 8, *B*).

Cementation.—Immediately after cementation and before the cement has set, the gold margins are burnished. Care should be taken to apply a counter force with an instrument on the lingual side of the inlay to oppose the burnishing force applied on the labial margin. Otherwise, burnishing may dislodge the restoration. After cementation of the inlay, the separated teeth will move and contact will be restored (Fig. 9).

Class III Inlays in Lower Anterior Teeth.—The same technique is used for class III restorations in lower anterior teeth. However, since the lower teeth are smaller and thinner, smaller burs and stones are used in the preparation (Fig. 10).

CLASS IV INLAYS

The preparation for class IV inlays is basically the same as that for class III restorations. The only difference is made in the treatment of the incisal angle (Fig. 11).

Although the restoration of a broken angle of a tooth by silicate cement backed with gold will give good service, it is not ideal esthetically. In time, the silicate

cement will change color because of its solubility in the fluids of the mouth. Its surface becomes etched and retains stains from tobacco or food. However, if the patient is willing to have the silicate cement replaced at regular intervals, it is a worthwhile restoration.

Removal of Decay.—The remaining decay is removed, and the pulp is protected first in the same manner as for class III cavities. The missing angle is not built up with cement at this time. If the line of fracture on the labial surface extends further gingivally than on the lingual surface, the angle should be built up with cement approximately 1 mm. above the lingual line of fracture to form a lingual incline.

No separation is necessary if the fracture has been sustained recently and if the tooth has not shifted. If the fracture has been long standing, the tooth will tend to rotate and the proximal space will be reduced. The tooth must be moved to its normal position prior to the preparation of the tooth.

The slicing technique is similar to that for class III cavities, except that the slice ends at the line of fracture.

Resistance and Retentive Form.—The horizontal alignment of the grooves and the incisal step contribute to both resistance and retentive form (Fig. 11). The pulpoaxial wall (which is part of the box) is continuous with the incisal step. Their common line angle is rounded for additional strength.

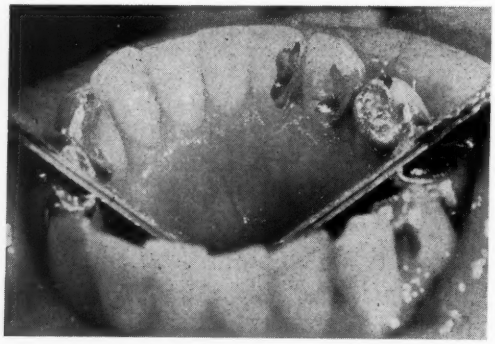
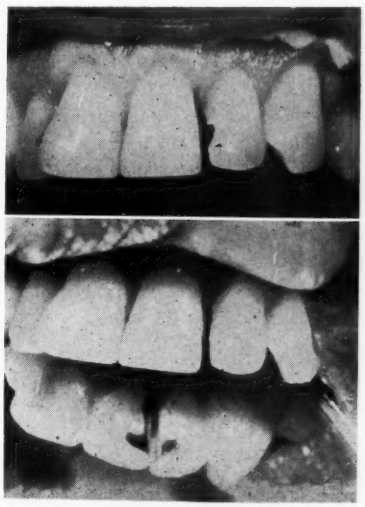


Fig. 9.—Class III inlays on the lower left incisor and canines.

The gingival groove is made at the gingivoaxial angle of the box, as in class III preparations. The incisal step is ended at the middle of the opposite axial third and is sunk gingivally into the middle third of the crown. The base of the incisal step is slightly dovetailed and made about 2 mm. deep, depending upon the labiolingual width of the tooth. Together, the gingival groove and the incisal groove form strong undercut retention. The preparation must be checked and beveled as for a class III inlay.

Interocclusal Wax Record.—An interocclusal record of centric occlusion is made in wax and chilled. The wax record is held in place on the upper teeth, and the patient is instructed to open the mouth then close the teeth into the wax to

A.



B.

Fig. 10.—*A* and *B*, Slow separation is used to treat an overlapping lateral incisor. The space is maintained between the sittings. The tooth will move back to its previous position after the restoration is cemented.

loosen it from the lower teeth. Then, with the teeth again in centric occlusion, the labial portion of the wax is cut off of the upper part of the wax record, leaving 1 mm. extending over the labial incisal edge of the tooth. The wax record is then removed by pushing it lingually. In this way, little distortion of the grooves in the wax will occur.

This wax record is adequate for reproducing the missing angle and the contact point and for determining the incisal and lingual relation with the lower incisors.

The relationships are reversed for restorations placed in the lower anterior incisors.

The trays and technique for making impressions for class IV inlays are exactly the same as for class III inlays (Figs. 4 and 5).

Wax Pattern for Restoration of a Fractured Angle.—In waxing the pattern, the angle is first reproduced in full. Then, a part of the labial surface of the pattern is carved out. All of the labial margins of the wax pattern, including the part in contact with the seat of the fracture, are cut back approximately 0.5 mm. in such a way that they do not show from the front or the side. The margins of the pattern terminate labially in a knife edge of the cut out pattern. The lingual wall should remain thick enough for adequate strength.

After cementation, all cement is removed from the reconstructed angle (Fig. 12, *B*). The box part of the casting and the edge of the fractured tooth are undercut for retention of silicate cement. Then the inside of the gold box in the casting is opaqued or masked with a thin layer of oxyphosphate of zinc cement of the proper shade (Fig. 12).

Before insertion of the silicate cement, a transparent crown form is cut to conform to the broken corner of the tooth. The edges of the celluloid form should extend beyond the fracture line of the tooth. To prevent air from being trapped and to allow the excess silicate cement to escape, a hole is made at the deepest corner of the crown form.

THREE-QUARTER CROWNS

Three-Quarter Crowns for Anterior Teeth.—Many anterior teeth with intact labial surfaces have been restored by full coverage even though it is often impossible to match the adjacent teeth perfectly. If the labial surface of *any type of tooth* is in an esthetic condition, a three-quarter crown inserted from the lingual side of the tooth can be used (Fig. 13).

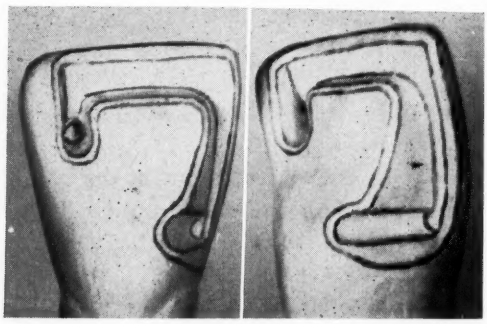
Preparation for a Three-Quarter Crown for an Abutment.—The labial finish line, or outline form of the preparation, is determined by the relative position of the tooth to the adjacent teeth. The tooth should be in normal alignment with lingual access.[7]

If the tooth is to be used as an abutment, an artificial tooth of the proper size is mounted on a small piece of shellac baseplate and placed in position next to the abutment tooth. This is used to determine the labial outline form of that proximal surface. The procedure is the same as for class III preparations.

On the lingual surface, the outline is varied with the labiolingual thickness of the tooth. On short and broad teeth, the lingual outline ends at the incisal edge as in the usual three-quarter crowns (Fig. 13). In flat teeth, the incisal third is left untouched (Fig. 14, *B*).

The proximal walls are sliced in the same manner as for class III preparations.

As in all preparations for inlays to be inserted from the lingual side of the tooth, the boxes, the incisal step, and the retentive grooves in the three-quarter



A. *B.*

Fig. 11.—The class IV preparation. *A*, Lingual view. *B*, Laterolingual view. The gingival groove and the slice are prepared as for a class III restoration (see Fig. 1). The incisal groove is carried to the opposite middle third of the tooth and is slightly dovetailed. Note the retention formed by the placement of the grooves. The line angle joining the pulpoaxial wall and the incisal step are rounded for strength. The grooves and the step provide resistance form. The incisal bevel is made in the same manner as for the usual three-quarter crown.

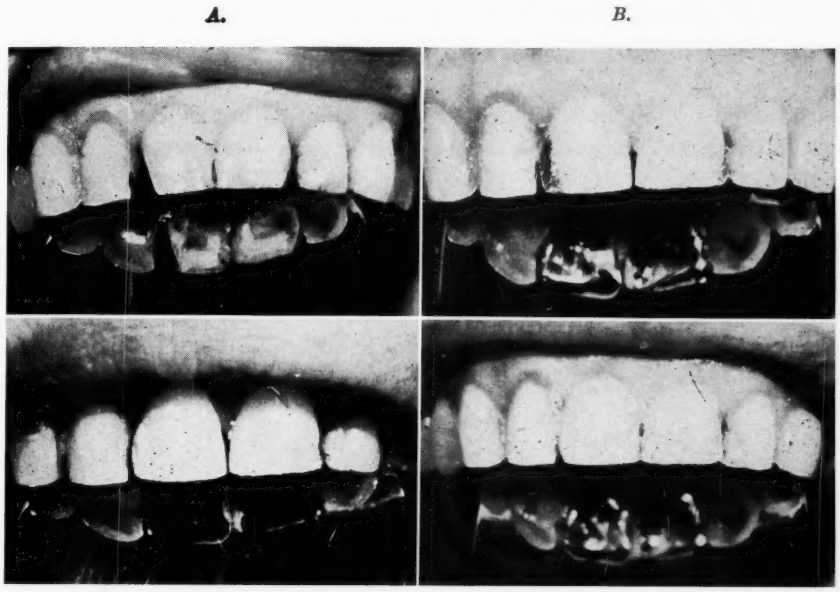


Fig. 12.—Two central incisors with attrition on the lingual surfaces and broken distal angles. *A*, The teeth after preparation. *B*, The class IV castings are in place, and the cement has been removed from the box in the castings. *C*, The gold is masked by cement of the proper color. *D*, The completed restorations.

crown take part in providing resistance form. The incising forces are nearly perpendicular to all of them.

Unless decay is present, the boxes are made narrow (about 1 mm. wide). The labioaxial wall should end about 1 mm. away from the labial outline of the slice. The boxes are used to give additional bulk, strength, and rigidity to the lateral gold walls of the three-quarter crown.

The incisal step is used on teeth that are thick labiolingually (Fig. 13). The floor of the step is parallel to the gingival floor of the boxes. It is continuous on either side with the axiopulpal walls of the boxes, joining them in rounded, rather than sharp, line angles. The incisal edge of the preparation is beveled at a 45 degree angle as for the usual three-quarter crowns. The size of the tooth, its labiolingual thickness, and the purpose for which the restoration is made will determine the number of grooves necessary. Four to five grooves may be made. A crown which is to serve as an abutment will require more retentive grooves than one to restore a carious tooth.

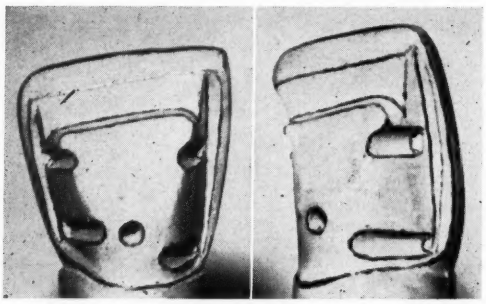
Three-Quarter Crown to Restore a Single Tooth.—When a carious tooth is to be restored by a three-quarter crown, the retentive grooves are replaced by two well-defined boxes with sharp incisal and gingival line angles (Fig. 14, *A*). If extra retention is required, a groove 1.5 to 2 mm. deep can be made in the cingulum. If the incisal third is not affected by caries, this preparation is essentially a combination of two class III preparations joined by including the middle third of the lingual surface in the preparation.

In a flat tooth with a translucent incisal third, the four groove three-quarter crown without an incisal step makes an invisible and strong restoration or abutment (Fig. 14, *B*).

Preparation.—With a small edge-cutting, self-limiting diamond disk, a 0.5 mm. mesiodistal cut is made on the lingual surface at the junction of the incisal and middle thirds of the tooth. This forms the incisal outline. Then, with a wheel stone or diamond, the middle and gingival thirds of the tooth are reduced to the same depth, bringing the gingival outline 1 mm. below the free margin of the gingiva.

After making the proximal boxes 1 mm. in width, the incisal grooves are placed about 1 mm. below the junction of the incisal and middle thirds. They are made 2 to 2.5 mm. deep, their depth determined by the width of the tooth in that region. Care must be taken to avoid cutting too closely to the labial surface. The grooves must be parallel to each other, but they are not placed in the same plane. A fifth groove in the cingulum is optional.

If severe attrition has occurred, with the danger of pulp exposure, the worn and rugged incisal edge is straightened slightly (Fig. 15, *B*). The allowance for adequate gold thickness is obtained by grinding the incisal edge of the opposing tooth or by increasing the vertical dimension of occlusion on the posterior teeth or dentures.



A. *B.*

Fig. 13.—The design of the preparation for a three-quarter crown made for insertion from the lingual side of the tooth. *A*, Lingual view. *B*, Laterolingual view. The same principles applied for making class III and IV restorations are combined in these preparations. The slicing, the grooves, the gingival finish lines, and the bevels are similar. Note that the grooves are not at the same vertical level although they are parallel to each other. The axioincisal step line angles are rounded. The boxes are about 1 mm. in thickness to give strength and rigidity to the proximal walls. The well at the cingulum is optional.

A two groove three-quarter crown is indicated for these worn teeth, with a third groove placed at the cingulum. The preparation is the same as for the four groove type, except that the two grooves are placed on the proximal surfaces at the thickest part of the tooth. This is usually at the junction of the middle third and the gingival third. The incisal edge is beveled as usual.

The bevel is placed either at the incisal edge, if a step is used (Fig. 13), or at the junction of the incisal and middle thirds, if no step is made (Fig. 14).

Impression Tray.—The impression tray is made in a manner similar to that used for class III inlays (Figs. 4 and 5). The only difference is that there are two lateral walls on the tray instead of one.

A wider piece of metal is used for the tray than for inlays. The two cuts (*CG* and *AB,* Fig. 4) are made in such a way as to leave between them an uncut width a bit greater than the mesiodistal width of the incisal edge of the tooth. The lateral walls of the tray are then bent forward and trimmed. Special care should be taken in fitting and contouring these trays (Fig. 5).

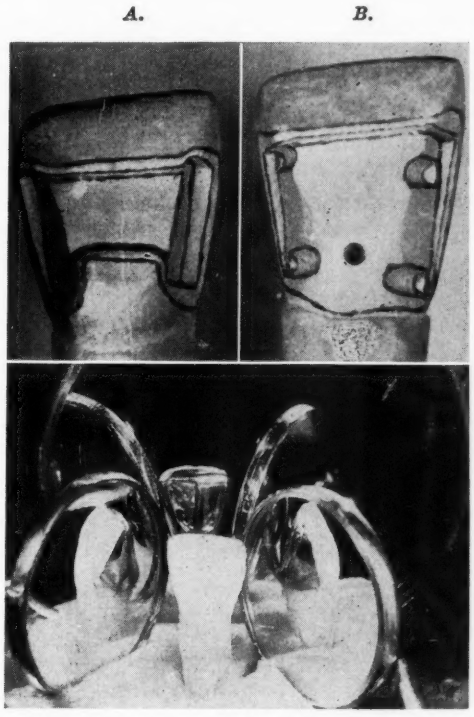


Fig. 14.—Preparations for teeth with thin translucent incisal thirds. *A,* A mesiolinguodistal combination of two class III restorations with lingual involvement. Note the proximal box retention. In weak teeth, the gingival margin can be carried further cervically, as in *B. B,* A well in the cingulum can be added for increased retention. *C,* A three-quarter crown on a tooth with a wide distomesioincisal edge and a narrow neck. The labial surface is left untouched, and no gold shows.

The impressions, dies, patterns, and castings are made by the same procedures as for class III inlays (Figs. 6 and 16).

Cementation.—In cementing this type of crown, air must not be trapped in the grooves or at the lingual gingival margin. The tube is used to inject the cement into the grooves in order to prevent the trapping of air in them.

The gingival crevice is first packed with cotton saturated with a solution of epinephrine, or a gingival packing is used. Then, before placement of the crown in position, the gingiva is pushed away by means of an appropriate instrument.

Indications.—A lingual access three-quarter crown can be used whenever the labial surface of the tooth is in good condition. It can be used also to restore a carious tooth or to serve as an abutment for a partial denture or as a component of a splint.

Advantages.—A three-quarter crown made by this technique exhibits no gold on the labial surface of the tooth, and it maintains the full mesiodistal width of that surface (Fig. 17). If desired, the incisal third of the tooth can be unchanged, because it need not have a gold backing. Thus, the crown does not affect the shade of the labial surface of the tooth. The labiolingual grooves provide both retentive and resistance form for the crown. Their locations are selected to preserve the strength of the tooth.

SUMMARY

An indirect technique for making gold inlays and three-quarter crowns for anterior teeth has been described. The unique characteristic of these restorations is that they are inserted from the lingual surface of the tooth rather than from the incisal edge. By use of this approach, an absolute minimum of gold is exposed on the labial surface of the tooth, and the translucency of the incisal third of the tooth can be maintained.

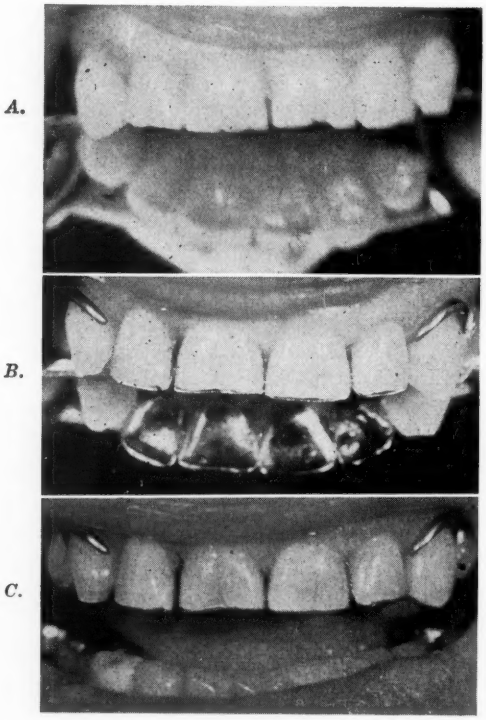
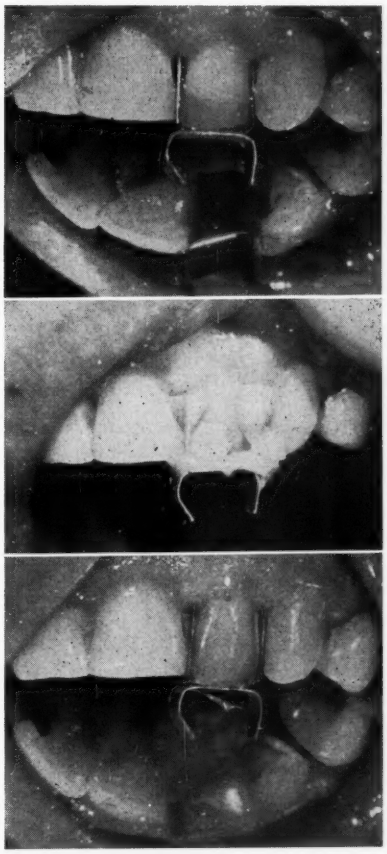


Fig. 15.—Restoration of badly worn teeth. *A*, The broken-down enamel of the incisal edges. *B*, The restoration of the teeth by means of three-quarter crowns. *C*, The excess gold on the incisal edges has been left for protection of the teeth.

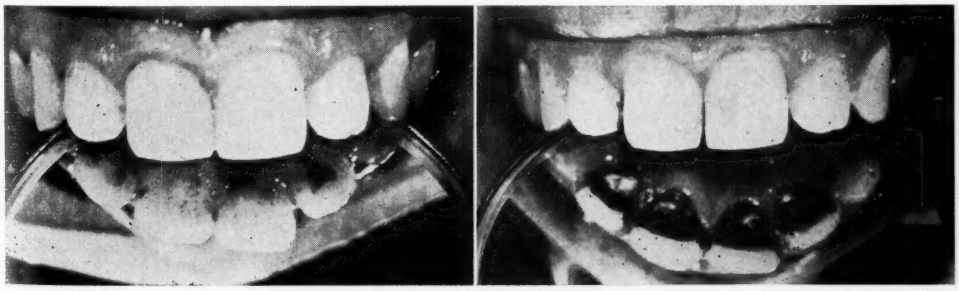


A.

B.

C.

Fig. 16.—The impression for a three-quarter crown. *A*, The tray is adapted to fit and conform to the prepared surface of the tooth. *B*, The impression is made. *C*, The impression is trimmed in a manner similar to that used for class IV cavities before it is removed.



A. *B.*

Fig. 17.—*A* and *B*, Three-quarter crown restorations. The teeth had extensive lingual and proximal decay.

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AMALGAM STRENGTH VALUES RELATIVE TO MERCURY PERCENTAGES AND PLASTICITY

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THE PURPOSE OF THIS STUDY is to investigate the concept that condensing a dry amalgam produces good amalgam. In order to make a dry amalgam, dentists use squeeze cloths or centrifuge machines or weigh precise percentages of alloy and mercury, all of which are intended to ensure a low mercury content in the finished filling.[1]

This report shows that amalgam is a strong material and that dryness does not improve its strength. On the contrary, dryness requires greater condensing force and adds the danger of lamination. An amalgam composed of equal parts of alloy and mercury by weight is dry by most standards. It is easily condensed and produces consistently higher strength values.

PROCEDURE

The tests were designed to establish values for mercury ratio, triturating time, and condensing force. The results were measured in crushing strength 1 hour and 1 week after condensation. No mercury was expressed before condensing, although some plashy amalgam was removed when 3 to 8 pounds of condensing force was used.

Each figure in Table I represents the average crushing strength of five tests. All specimens were condensed from one mix triturated* at one time. The mix contained two or three portions.

Five brands of alloy were tested, one of them in pellet form. For clarity and ease of comparing various techniques, all results are listed in Table I and references to the individual tests are made by letter.

Each specimen was condensed with a No. 1 serrated condenser, occasionally changing to a No. 2.† The mercury percentages were calculated before trituration. No mercury was removed with a squeeze cloth before condensation. The specimens were crushed in a testing machine‡ with a loading rate of 0.12 inch per minute, 1 hour and 1 week after condensation.

RESULTS

Technique A.—In this group, the amalgam consisted of equal parts of mercury and alloy. Five specimens were triturated for 15 seconds and condensed within

*Wig-L-Bug.
†Black.
‡Emory.

TABLE I. TECHNIQUES AND RESULTANT CRUSHING STRENGTHS (P. S. I.)

DESCRIPTION OF TECHNIQUE	ALLOY V		ALLOY W		ALLOY X (PELLETS)		ALLOY Y	ALLOY Z
	1 HR.	1 WK.	1 HR.	1 WK.	1 HR.	1 WK.	1 WK.	1 WK.
Technique A								
Trituration 15 seconds: 50 per cent mercury; condensed in less than 1½ minutes from start of trituration, using only light pressure, 1 to 1½ pounds; effort made to leave all mercury in the amalgam mass	14,560	55,660	11,700	55,700	9,200	57,100	59,200	60,400
Trituration 30 seconds: Otherwise same as above	17,600	65,900	15,600	60,000	11,500	56,700	66,800	62,900
Technique B								
Trituration 15 seconds: 50 per cent mercury; condensed in 2 minutes from start of trituration, with 3 to 8 pounds pressure; effort made to remove excess mercury	19,040	55,440	14,200	56,300	11,800	50,600		
Trituration 30 seconds: Otherwise same as above	23,900	63,900	18,300	59,800	11,500	58,700		
Technique C								
Trituration 15 seconds: 47 per cent mercury; condensed in 2 to 2½ minutes from start of trituration, with 3 to 8 pounds pressure; a little excess mercury removed	18,860	58,260	16,800	55,400	12,300	58,500		
Trituration 30 seconds: Otherwise same as above	21,120	65,000	17,700	56,300	16,100	55,700		
Technique D								
Trituration 15 seconds: 50 per cent mercury; waited 3 minutes from start of trituration, then condensed with 3 to 8 pounds pressure; some excess mercury removed; total time from start of trituration 5 minutes	16,960	57,600	12,200	53,700	10,200	53,000		

1½ minutes after the start of trituration. The condensation force was light, about 1 to 1½ pounds. As far as was possible, no mercury was removed in condensation.

The mass of amalgam was wet by average standards. Heavy condensing force would have pushed holes through the mass. Most dentists would not be satisfied with the feel of the material. The results show greater strength after 1 hour and 1

week when compared to tests on conventional alloy-mercury ratio and condensation techniques.[2]

Thirty seconds of trituration produced a drier mix than the 15 second samples. The amalgam was crepitant and viscous. A slightly greater thrust was necessary to condense this mix. With the exception of the pellets, all the crushing values were higher than for the 15 second mix.

Technique B.—In this technique, the major change was an increased condensing load, 3 to 8 pounds. There was a slight increase in condensing time, and excess mercury, in the form of plashy amalgam, was removed.

In general, the average values for crushing strength showed an increase at the end of 1 hour when compared to those of amalgam condensed with light force and similar trituration time. However, the specimens tested after 1 week were about the same as those condensed with light pressure (technique A).

Technique C.—This technique was essentially the same as technique B, except that instead of equal parts of mercury and alloy, the mercury was reduced to 47 per cent and the alloy increased to 53 per cent. The condensing time was increased slightly, and a small amount of mercury was removed as the plashy amalgam was discarded. The condensing force was from 3 to 8 pounds.

The amalgam mix, so far as its texture was concerned, was about the equivalent of that most dentists try to create when using a squeeze cloth. It had more resistance to the packing thrust and a certain amount of body, which encourages more vigorous condensation. While the results of this technique were comparable with those of the other two methods, there was no clear-cut advantage in using 47 per cent mercury.

Technique D.—This investigation was designed to test the hypothesis that amalgam is usable for only 3 minutes after the start of trituration.

The amalgam consisted of 50 per cent mercury and 50 per cent alloy. It was triturated for 15 seconds. No excess mercury was expressed. The specimen was condensed after waiting 3 minutes, using 3 to 8 pounds pressure. Some excess mercury was removed in condensation. The condensation was completed 5 minutes after the start of trituration.

The crushing strength of the amalgam specimens in this group was only slightly less than that of those condensed within the 3 minute period (techniques A, B, and C).

CLINICAL TESTS

Laboratory tests are conducted under controlled conditions with every effort made to eliminate human variables. It is impossible for a group of dentists to reproduce results similar to laboratory tests, since individual techniques such as force and times of trituration and condensation vary.

In order to determine the average crushing strength of amalgam prepared and condensed under office conditions, nineteen practicing dentists supplied ninety-five specimens of amalgam. They were instructed to prepare the samples precisely as if they were for patients, using their routine trituration and condensing techniques.

Many of the office techniques emphasized dryness, but these did not consistently produce the strongest. It is interesting to note that the average crushing strength of the clinical specimens did not favorably compare with that of the laboratory test specimens. The average crushing strength was 42,900 p.s.i. (range 29,000 p.s.i. to 63,000 p.s.i.).

SPECIMENS CONDENSED BY CHILDREN

A group of children 8 to 15 years old, without previous experience, were taught to triturate and condense amalgam. The amalgam contained equal parts of mercury and alloy and was triturated for 30 seconds. The children produced twenty-five samples which averaged 50,800 p.s.i. crushing strength 1 week later. These results, superior to the results of the dentists, were still below the standards of the laboratory-prepared amalgam (techniques A, B, C, and D).

SPECIMENS CONDENSED BY VIBRATION

In order to further test the merit of a heavy condensing force, five specimens of amalgam were packed by using a laboratory vibrator. No instruments were used to condense the amalgam. In this study, the percentage of mercury was raised to 60 per cent, approximately the same as advocated by most manufacturers. These specimens averaged 43,000 p.s.i. after 7 days.

DISCUSSION

Crushing Strength.—In an effort to establish a desirable crushing strength for amalgam, the American Dental Association Specification No. 1 established 35,500 p.s.i. as the minimum. This requirement was later abandoned in favor of a flow test which, in effect, corresponds to a crushing strength test.

Most laboratory amalgam specimens surpass the original crushing strength test. Ryge and associates[2] found that the average crushing strength of amalgam specimens, packed either by hand or mechanical condensers, reached 45,830 p.s.i. after 7 days. However, Miller[3] pointed out the clinical need for high crushing strength in the first hour. It is during this time that the filling can be fractured. He also cautioned the dentist to make sure that no part of the restoration is left too high.

It is almost impossible to determine the required clinical strength of an amalgam filling. The stress on an amalgam restoration during function has never been determined. Hoppenstand and McConnell[4] tested the crushing strength of class I amalgam restorations in ivorine teeth. The amalgam consisted of five parts of alloy to six parts of mercury (roughly 55 per cent mercury) and was triturated for 12 seconds. The amalgam fillings tested in ivorine teeth failed after 24 hours to withstand 500 pounds of pressure. Unfortunately, the report does not make clear whether the ivorine teeth or the amalgam failed.

Apparently, amalgam has adequate crushing strength 1 week after insertion. However, the first hour is the critical period. Healey and Phillips[5] observed that 82 per cent of all amalgam restoration fractures occurred because of faulty manipu-

lation and that low crushing strength was the cause. Since the low mercury ratio technique[1] provides higher strength during the first hour, this technique should reduce the incidence of fracture.

From these data we must concur with Keys[6] that the material being used is acceptable and that if filling failures still occur, cavity preparation and matrix adaptation are probably the two most neglected steps in amalgam procedures.

Condensation.—There is no best method for condensing amalgam. Early techniques recommended starting with wet increments followed by successively drier masses of amalgam. Mosteller[7] advocated wringing the mercury from the entire mass so that, in theory, the bottom and top portions of the filling would be the same.

A recent report[8] showed that amalgam of extremely low mercury content, even as low as 25 per cent, can be condensed by hand to yield high strength values. However, amalgam with a low mercury ratio had the same compressive strength after 7 days as that prepared according to mercury ratio recommended by the manufacturer. The report advocates a ratio with 50 per cent mercury for clinical use.

Dentists are aware of the danger of excess mercury. The newer method is to control the amount of mercury in the mix rather than wring out the excess. However, as the mercury content is decreased, the condensing thrust is increased. This is a dangerous procedure because, unless small diameter instruments are used, lamination and porosity may result.

Condensation and Compressive Strength.—The results of this study seriously question the value of heavy condensing force. The dry mix of amalgam, which encourages heavy condensation, does not materially increase the compressive strength. The clinical tests by nineteen practicing dentists, many of whom emphasized dryness, did not produce high strength values after 7 days. Comparable values were produced by vibrating a wet mix.

Using a wet amalgam will enhance the use of threaded wire reinforcing pins as described by Markley.[9] The plasticity of the amalgam is more likely to result in maximal retention into the grooves of the pins, since the dry amalgam is difficult to condense laterally.

Condensing Technique.—The condensing technique used in this study deviates slightly from the conventional methods. Better cohesion of amalgam increments results from thrusting the condenser into the previously placed material and at the same time thrusting somewhat laterally. This tends to condense the amalgam against the walls of the cavity. The lateral thrust, particularly important when using a dry amalgam, minimizes the danger of lamination, which is likely to occur from direct vertical thrusts that tend to tamp the amalgam against the preceding layer.

A moderately serrated condensing point of any design is advocated because it will attach to and move amalgam without burnishing it. Removal of about one-half the depth of the serrations of the condenser is recommended. The shortened serrations remain cleaner, and it is easier to move the instrument laterally. The serrations may be reduced with an abrasive disk in a few seconds.

Undertrituration and Overtrituration.—There can be no doubt that undertrituration results in inferior amalgam. It will cause overexpansion and corrosion.[10] On the other hand, overtrituration produces stronger amalgam (Table I).

A limited number of tests for dimensional change were conducted under the techniques described in Table I. Some of the specimens showed a slight contraction. It has, however, been shown[8] that shrinkage does not always occur. The increased early strength may be more desirable than the slight shrinkage which may not be clinically important.

Throughout this entire study, one significant observation surpasses all others. Amalgam is inherently a strong material. The crushing strength values of amalgam specimens, whether packed by skilled or unskilled hands or even vibrated into a mold, is high. It is emphasized that the use of dry amalgam can be highly satisfactory, but it requires greater skill and the possibility of error is greater. Increasing the mercury ratio to 50 per cent ensures a more plastic mass which is easier to condense into the cavity with equally good results.

This study confirms the findings of Swartz and Phillips[11] that a mercury content of 45 to 53 per cent is not critical, but that when the residual mercury reaches 55 per cent, the amalgam is inferior. We believe that by using a 50 per cent mercury ratio, longer trituration time, and light condensation force, it is easier to produce consistently good amalgam restorations.

CONCLUSIONS

1. Lightly condensed amalgam specimens containing 50 per cent mercury from which no excess mercury was removed had high crushing strength. They compared favorably with specimens condensed under pressure with excess mercury removed during condensation.

2. Thirty seconds of trituration resulted in a drier mix and higher crushing strength than 15 seconds of trituration.

3. Specimens permitted to crystallize for 3 minutes before condensing in 2 minutes were well within acceptable strength ranges.

4. Clinical observations indicate that consistently better condensed and stronger amalgam restorations result from a wet mix than from an excessively dry mix.

5. All brands of alloy gave acceptable high strength values for 1 hour and 7 days. The pellets had a lower crushing strength after 1 hour.

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MINIATURE PARALLEL PINS FOR RETENTION OF CAST RESTORATIONS

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RETENTION IS A MAJOR PROBLEM in fixed partial dentures. The value of pins for retention in cast restorations is well known. However, the inability of most dentists to drill multiple parallel pinholes has limited their use.

INTRAORAL ALIGNING DEVICE

A mechanical intraoral aligning device permits multiple miniature parallel pinholes to be drilled in abutment teeth.[1,2] This paralleling device† is simple and compact; it consists of a drill bushing mounted eccentrically within a plastic disk. The disk rotates freely or slides in two dimensions within a channel frame (Fig. 1).[3] The device is secured directly to the teeth with modeling compound (Figs. 2 and 3) or adapted to a mounting post attached to an acrylic resin baseplate (Fig. 4).

The pinholes are made with a 2.5 by 0.6 mm. diameter special drill† which is adapted to fit loosely within a contra-angle handpiece (Fig. 5). The adaptor end of the drill is tapered to permit a loose, wobbling movement while the drill is in operation, thereby creating the effect of a universal joint.[3] The drill bushing guides the drill irrespectively of the angulation of the handpiece.

FABRICATING THE CASTING

A nylon bristle technique is used to cast gold pins which accurately fit the pinholes of a cavity preparation.[4] The 0.6 mm. drill produces a pinhole 0.024 inch in diameter into which 0.022 inch diameter nylon bristles are inserted before making the impression. Each bristle has a flat knob on the end which projects 2 to 3 mm. from the orifice of the pinhole (Figs. 6 and 7). Thus, the impression material holds the bristle firmly in proper position while the artificial stone die is poured (Fig. 8). Reversible hydrocolloid, silicone, and rubber-base materials have all been used successfully for making the impressions.

After the die has been formed, the nylon bristles are used to help form the wax pattern. Size 0.020 inch diameter bristles are inserted in the pinholes of the die to facilitate withdrawal of the wax pattern. The bristles are cut with a hot

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Presented before the American Academy of Crown and Bridge Prosthondontics in Chicago, Ill.

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Fig. 1.

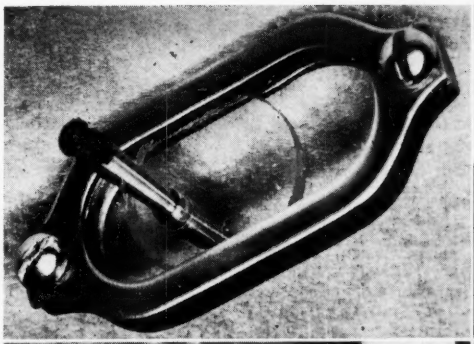

Fig. 2.

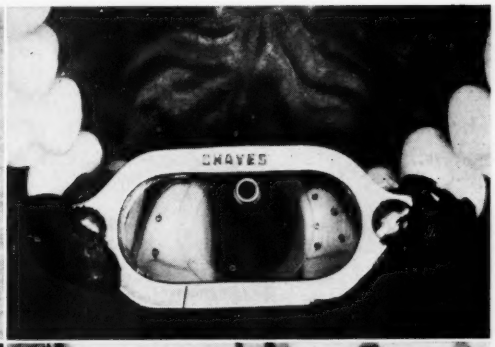

Fig. 3.

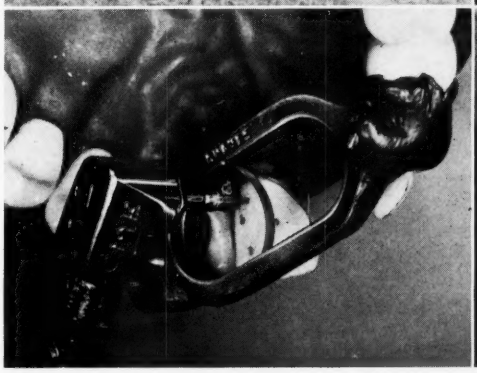

Fig. 4.

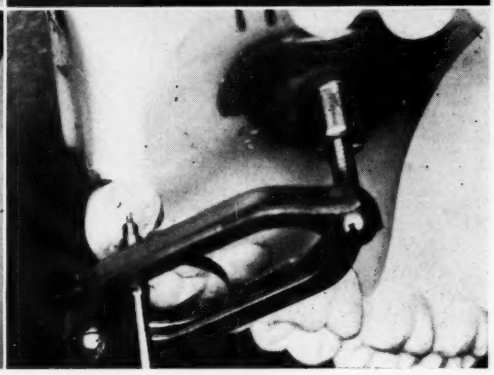

Fig. 1.—The parallelometer has a special drill inside a drill bushing.
Fig. 2.—The parallelometer is mounted on the teeth with modeling compound.
Fig. 3.—The pinholes are drilled in two abutment teeth.
Fig. 4.—The parallelometer is mounted on an acrylic resin palatal baseplate.

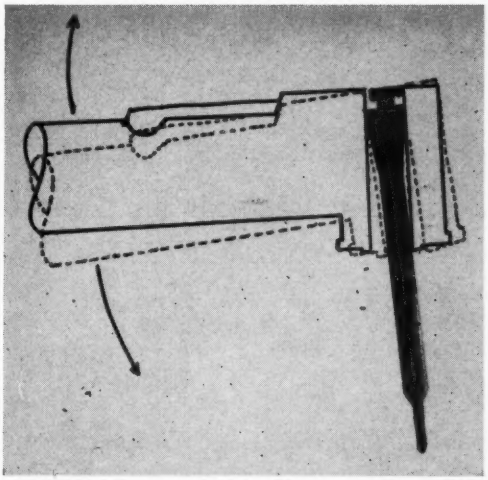

Fig. 5.—A special drill is mounted in a handpiece that allows free movement without altering the angulation of the drill. (From Curtis, G. H., and Baum, L.: J. Periodont. 31:394, 1960.)

instrument or sharp razor blade so that about 0.5 mm. projects above the surface. Wax is added to contour the pattern, which is removed, invested, and cast. Type C, or partial denture, gold is used for abutment retainers.

Slight discrepancies in the casting may be found around the base of each pin. These are caused by the high melting temperature and high thermal coefficient of expansion of nylon. The nylon expands before it melts within the mold cavity and

Fig. 6.

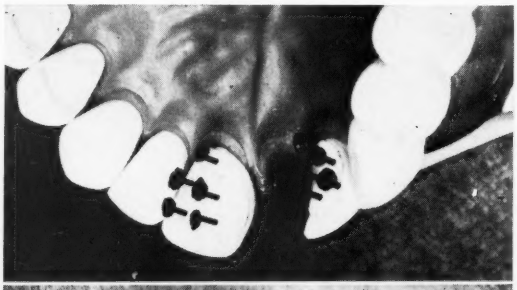

Fig. 7.

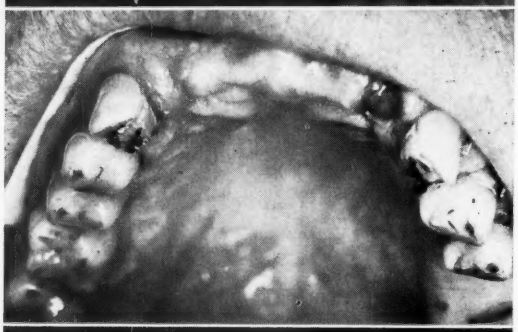

Fig. 8.

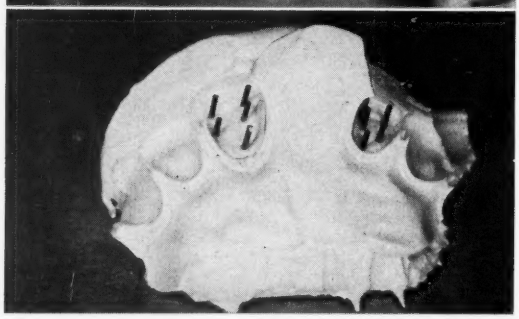

Fig. 6.—Nylon bristles (0.022 inch diameter) are placed in pinholes prior to making the impression.

Fig. 7.—Three-quarter crown cavity preparations are completed on short cuspid abutment teeth. The nylon bristles are in the pinholes for making the impression.

Fig. 8.—The bristles are fixed firmly in the final impression.

thereby fractures fragile or sharp corners of the investment. These discrepancies are relieved by chamfering the orifice of each pinhole in the tooth with a No. 4 round bur, thus creating a slight relief area around the base of each pin. Occlusal adjustment of the casting is done either in the mouth or on the articulator.

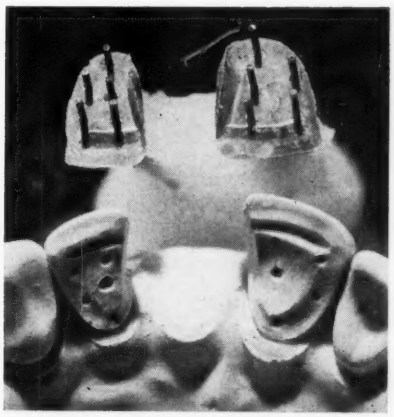

Fig. 9.—The die and abutment castings show the pinholes and pins.

CEMENTATION OF THE CASTING

Oxyphosphate of zinc cement is used for cementation of the restoration. A large volume of cement (fifteen to twenty drops of liquid) is mixed to a thin consistency on a cool slab. A copious supply of cement is placed on the exposed part of the tooth and on the inside of the casting. The casting is seated on the prepared teeth. The casting is removed, more cement is added, and the casting is again seated. This procedure is repeated a third time if the consistency of the cement permits. The gold pins serve as tiny plungers inside the walls of the pinholes, and by hydraulic action the cement is pumped into the space and the air bubbles are eliminated.

Because of the surface tension of the cement and the difficulty of introducing it into pinholes, one might expect trapping of air bubbles to be a matter of serious concern. However, this problem is more academic than clinical. The size of the pinhole is so nearly the size of the cast gold pin that a space of approximately 0.002 inch is available for cement. A film of cement will adhere to the gold, automatically displace the air within the pinholes, and adequately fill the space.

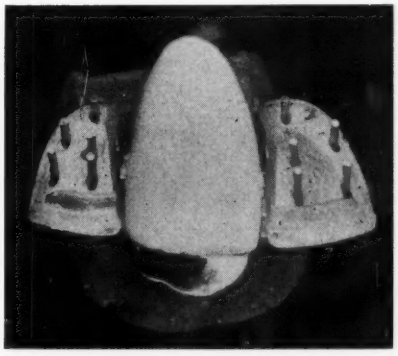

Fig. 10.—The finished fixed partial denture is ready for insertion.

ALTERATION OF CAVITY DESIGN

Miniature parallel pins enable the dentist to use different cavity designs, particularly for anterior teeth (Figs. 9 and 10).

PARALLEL PINS FOR THREE-QUARTER CROWNS

The path of insertion of the classic cast gold anterior three-quarter crown does not lend itself to the structure of the incisor teeth (Fig. 11). The widest part of the tooth, the contact area, is near the labial surface. Consequently, a casting inserted from the lingual surface requires removal of less tooth structure than a casting inserted from the incisal end of the tooth. The preparation of the three-quarter crown often necessitates the sacrifice of the proximal incisal angles to remove undercuts that are gingival to the contact areas. A casting inserted from the lingual side can reach the carious areas without sacrificing these esthetically strategic proximoincisal corners. Thus, a lingual approach provides a conservative outline form, has an esthetic result in displaying little or no gold (Figs. 12 and 13), and does not require paralleling of opposing walls or axial grooves (Fig. 14).

GOLD CASTINGS WITH SILICATE WINDOWS

Incisors with badly broken-down proximal silicate fillings are often restored with veneer crowns for reasons of esthetics. A conservative alternative approach consists of a gold casting with silicate windows.

A casting inserted from the lingual side of the tooth lends itself much better to the placement of a silicate window than does a three-quarter crown which is

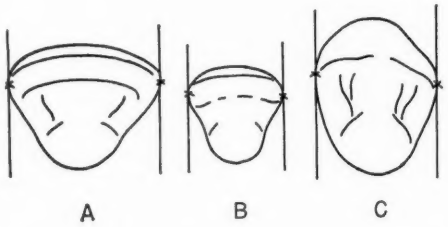

Fig. 11.—An incisal view. *A*, The maxillary central incisor. *B*, The mandibular central incisor. *C*, The maxillary cuspid shows that the greatest mesiodistal width lies well toward the labial surface.

inserted from the incisal end of the tooth. The preparation is made in the usual manner. However, the proximal finish line is arbitrarily terminated in the labial embrasure just labial to the contact area.

The casting is made and fitted to the tooth. Then, the labial margin of the casting is cut back to create a junction line which will provide optimal esthetic appearance. The silicate windows are inserted after the casting is cemented.

The most vulnerable site of breakdown of a silicate restoration is gingival and lingual to the contact area. Inasmuch as this part of the tooth is restored with gold, the life expectancy of the silicate filling is much longer. However, if the silicate filling needs replacing, it can be done without disturbing the gold casting.

PARALLEL PINS FOR MAXILLARY CUSPIDS

The use of miniature parallel pins provides an improvement in cavity design for maxillary cuspids. A sound maxillary cuspid is often used as an abutment. Usually the most conservative approach calls for a three-quarter crown which destroys the natural mesial surface of the tooth and results in a display of gold along its mesial margin. A conservative, strong, and esthetically acceptable preparation can be made when parallel pins are used (Fig. 15). The mesial contact of the tooth is not included in the preparation, and the finish line terminates along the mesiolingual marginal ridge.

The distal slice and the incisal and axial grooves are placed in a conventional manner in this preparation. The parallelometer is mounted with modeling compound on the occlusal surface in a direction parallel to the axial groove. Three to four pinholes are placed along the mesiolingual marginal ridge and in the cingulum. The casting has retention which is positive and precise. This cavity design (pins and grooves) lends itself to many different applications (Fig. 16).

Fig. 12.

Fig. 13.

Fig. 14.

Fig. 12.—An anterior fixed partial denture replaces the central incisors.
Fig. 13.—Note the lack of display of gold when the restoration is in the mouth.
Fig. 14.—The path of insertion permits the preservation of the distoincisal angle of the maxillary central incisor.

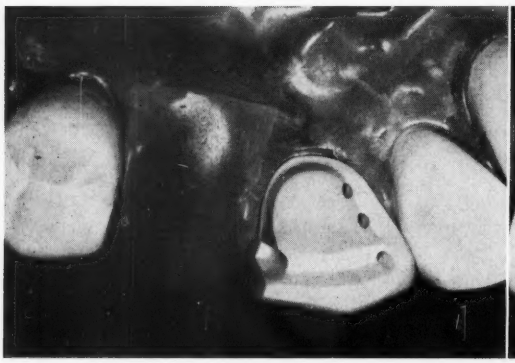

Fig. 15.

Fig. 16.

Fig. 15.—The cuspid preparation preserves mesial surface contact without sacrificing strength.

Fig. 16.—A conservative bicuspid cavity preparation combines pins with a proximal box.

PARALLEL PINS FOR POSTERIOR TEETH

Miniature pins in parallel alignment can give retention to restorations for almost all posterior teeth despite the degree of destruction and the lack of remaining clinical crown. The smallness of the drill (slightly less than a No. ½ round bur) permits the placement of pinholes around the border of most pulps without perforating the side of the root (Figs. 17 and 18). The pins can also be placed in the roots of incisors (Fig. 19).

MOUNTING THE PARALLELOMETER

The parallelometer may be mounted either directly on the teeth or on a resin baseplate to place the pinholes for badly broken-down teeth (Figs. 4 and 20). The baseplate technique is more time consuming but permits the dentist to remove the apparatus and inspect the pinholes before they are all completed.

The baseplate is made of quick-curing acrylic resin which is adapted to fit a diagnostic cast of the patient. After the parallelometer is properly positioned for drilling the pinholes, the assembly is carried to the mouth and held firmly in the palate while the drilling is done.

The baseplate mounting is also suitable for mandibular posterior teeth. The baseplate is built arbitrarily on the diagnostic cast to bridge the tongue and floor of the mouth. When the baseplate is placed in the mouth, the tongue and sublingual tissues are easily depressed to permit the baseplate to seat on the lower dental arch.

TEMPORARY PROTECTION OF EXPOSED CAVITY PREPARATIONS

A tooth with miniature pinholes cannot remain in contact with the saliva for a period of time without creating sensitivity or pulpitis. A preparation of this sort may lead to sensitivity within a few hours when exposed to saliva. The pinholes cannot be sealed with zinc phosphate cement because it is extremely difficult to remove.

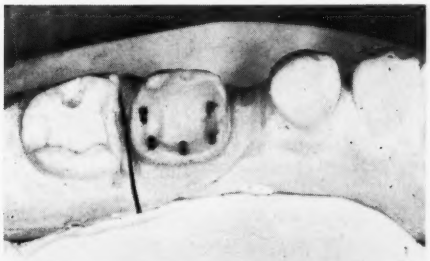

Fig. 17.

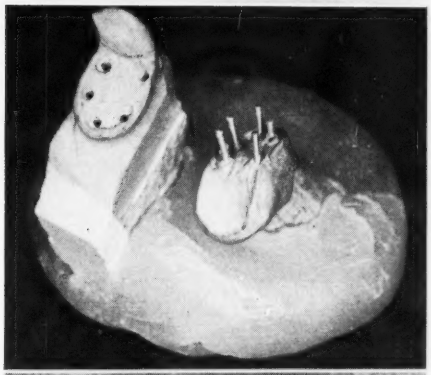

Fig. 18.

Fig. 19.

Fig. 17.—Nylon bristles (0.020 inch diameter) are in the pinholes of the artificial stone die.

Fig. 18.—A die and casting are constructed for a broken-down vital bicuspid.

Fig. 19.—Retentive pinholes are placed in the root of a vital abraded central incisor.

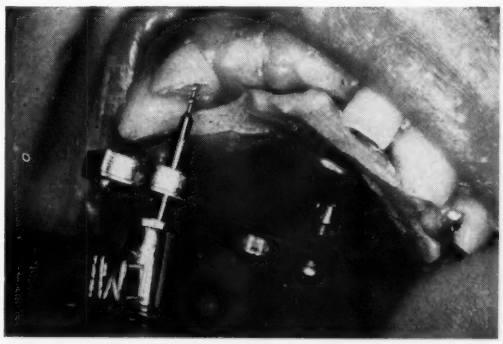

Fig. 20.—The parallelometer is mounted on an acrylic resin baseplate.

Three types of protectors or guards have been used successfully. A temporary gold casting may be made and cemented with zinc oxide–eugenol cement if a prolonged, multiappointment procedure is anticipated.

An aluminum or celluloid crown may be cemented as temporary protection provided the pinholes are first filled with short lengths of nylon bristle or No. 20 sewing thread which has been dipped in sticky wax. A No. ½ round bur can be used with a light touch to remove cement that may enter the pinholes.

Quick-curing acrylic resin may also be used over short lengths of bristle or waxed thread which have been inserted into the pinholes. Usually the resin can be worked through a gingival embrasure or over the incisal edge of the tooth so that suitable locking can be obtained from the labial surface. This type of temporary protection will last from 7 to 10 days.

The dentist should schedule patients so that a minimal period elapses from the time of preparation until the final cementation of the restoration. The pontics should be fittted before the abutment teeth are prepared for fixed partial denture restorations.

If pulp exposure should accidentally occur, the pulp in the affected pinhole is covered with calcium hydroxide and the pinhole is filled with oxyphosphate of zinc cement. Some teeth which have been exposed and capped under sanitary conditions have been successfully used as abutments for more than 18 months.

SUMMARY

The use of miniature parallel pinholes in cavity preparations for cast gold restorations permits the dentist to use a less stereotyped cavity design. A method of achieving parallelism in alignment of pinholes with subsequent alteration in cavity design has been described. This cavity modification is useful for maxillary cuspids, incisors, and badly broken-down crowns of posterior teeth. Inasmuch as precision-fitting cast gold pins are not in widespread use, some of the clinical problems peculiar to their utilization were described.

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INTENTIONAL VITAL PULP EXTIRPATION IN PERIODONTAL PROSTHESIS

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DURING THE PAST FEW YEARS, the subject of endodontic therapy in relation to oral rehabilitative procedures has received some attention in the literature. Most of the articles have presented a generalized approach to the subject, mainly from the standpoint of indications and techniques.[1,2] Also, there have been several reports devoted to the utilization of endodontic procedures in periodontally involved teeth.[3-6] In patients with minimal periodontal destruction, the restorative dental program (other than in the presence of rampant caries) is generally satisfied by the procedures of operative dentistry. Naturally, these restorative procedures have an effect on the periodontium and are an important factor in the prevention and treatment of marginal lesions as well as in periodontal maintenance. Endodontic correction is a commonly accepted procedure in relation to operative dentistry, and as such it is not a part of this discussion.

Advanced periodontal destruction introduces an entirely different set of circumstances and conditions (Fig. 1, *A*). The inherent problems of gross bone loss and weakened attachment are present. These problems are further complicated by the oral changes incident to tooth loss and the need for replacement of missing members of the dental arch. In the past, the prognosis of this type of case was considered unfavorable for restorative procedures and, hence, an indication for complete dentures. However, through periodontal treatment many of the "hopeless" teeth have been shown to be capable of survival. Advanced restorative techniques have provided an indispensable contribution toward this end (Fig. 1, *B*). These techniques have led to the introduction of many new technical problems and, more important, to a concomitant revision in the basic concept of restorative dentistry. With this revision, each component part of the remaining dental mechanism has assumed a position of importance relative only to its role in preserving the dentition as a whole. *No tooth, or component of a tooth, should be regarded as sacred if the prognosis of the remaining dentition is improved by its sacrifice.* Regard for the preservation of tooth structure becomes false conservatism if, through this preservation, the prognosis of the entire masticatory mechanism is endangered. Every operative and therapeutic procedure so far developed has involved the sacrifice of some healthy tissue to eliminate disease. This is as true in general surgery as it is in restorative dentistry, periodontics, and endodontics.

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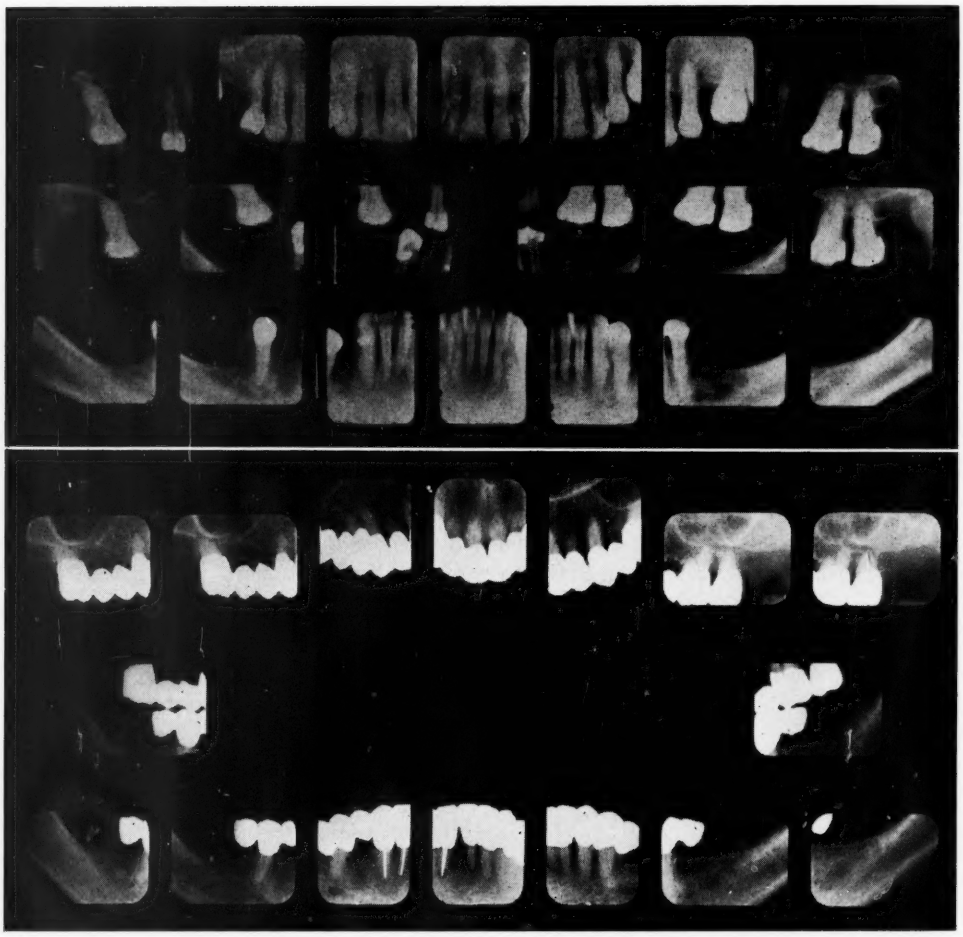

B.

Fig. 1.—*A,* Advanced periodontal destruction. More than one-half of the supporting bone has been lost, which leads to tooth mobility and adverse crown-root ratio. *B,* Postoperative roentgenograms show the endodontically treated left maxillary second molar and the right mandibular lateral incisor and cuspid. The pulp was removed from the maxillary molar to aid in the placement of a splint.

PERIODONTAL PROSTHESIS

In periodontal disease, procedures of oral rehabilitation or periodontal prosthesis are commonly employed. Splinting techniques utilizing the full veneer crown[7] occupy a prominent position in these procedures (Fig. 2). Although this involves the removal of sound tooth structure, periodontal prosthesis has been necessary in order to restore missing teeth and to preserve the existing dentition. Pulp exposure in tooth preparation or pulpal death as a result of such preparation is admittedly a part of the price paid for this therapy. Endodontic therapy has provided a successful means of treating these situations, and this aspect of endodontic treatment has

been gratefully accepted. On the other hand, there has been little attention called to another phase of endodontic therapy in relation to restorative dentistry, namely, intentional vital pulp extirpation. For some reason, the pulp has remained so sacrosanct that extirpation of this vital area as an integral part of the restorative prescription has been unacceptable. Actually, pulp removal falls into the same category as removal of uninvolved hard tooth structure and should be viewed in the same way.

SUCCESSFUL ENDODONTIC TREATMENT

The degree of success of modern endodontic procedures is perhaps higher than that found in any other branch of dentistry. Studies[8] show the 5 year endodontic success rate to be approximately 95 per cent. At the same time, there is little reason to question the dependability of the root-filled tooth for abutment use in extensive restorations. However, even with the overwhelming number of root-filled teeth successfully functioning as abutments, there remains a reluctance on the part of many to remove the pulp of a tooth intentionally. Some dentists will go to great lengths, even extraction, to avoid such a procedure. In so doing, they complicate the technical aspects of the treatment and compromise the result. This approach seems incongruous. Today, there is little hesitancy to sacrifice sound tooth structure, gingival tissue, and even alveolar bone if this seems advisable for the maintenance of the affected dentition. Why then is there this reluctance toward removal of a vital pulp as a sound and acceptable form of therapy?

INTENTIONAL EXTIRPATION OF VITAL PULP

Planned, intentional extirpation is not a substitute for meticulous care during cavity preparation. Neither is it to be utilized as a method of avoiding the more conservative procedures of tooth movement. When indicated, pulp extirpation is an extremely important treatment. However, its use calls for intelligent planning, which means its inclusion in the original treatment plan. The necessity for this form of endodontic treatment should not arise unexpectedly during tooth preparation.

Intentional pulp extirpation has several indications: (1) reorientation of the occlusal plane, (2) reduction of the crown-root ratio of teeth, and (3) establishment of parallelism of clinical crowns.

Reorientation of the Occlusal Plane.—Patients with periodontal disorders who need extensive restorative measures seldom have intact dental arches. Deviations in the occlusal plane resulting from tooth loss and subsequent tipping, drifting, and elongation are common. The elimination of these conditions entails more than simple replacement of the missing teeth. Since the establishment of a consistent occlusal plane is of prime importance in the fabrication of a harmonious occlusion, deviations in the height of the teeth in the dental arch must be eliminated. Selective grinding procedures alone may or may not suffice to correct the irregularities. Frequently, a tooth has extruded to such an extent that pulpal exposure will result if the tooth is reduced to the proper position in the occlusal plane (Fig. 3). It may be necessary to remove the tooth, but in many instances, root canal therapy may per-

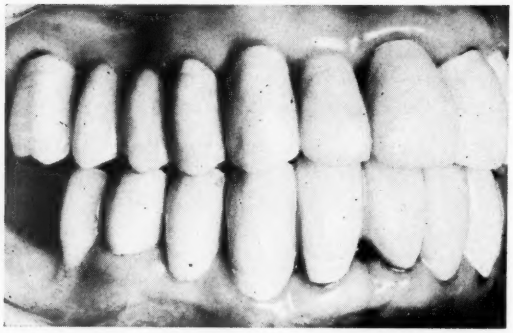

Fig. 2.—Maxillary and mandibular full arch splints utilizing gold crowns faced with acrylic resin.

mit the retention of the tooth in the arch. This decision would influence the type of restoration to be made. This alternative to extraction becomes increasingly important if there are few remaining teeth and even more important if the extruded tooth also happens to be the terminal tooth in the dental arch. Its importance as a terminal abutment makes its retention highly desirable, if not critical (Fig. 4). The retention of an extruded tooth often spells the difference between a fixed and a removable prosthesis and, from the standpoint of the patient, may be synonymous with success or failure. The prognosis often depends upon the number of teeth remaining and their position and distribution in the dental arch.

Reduction of Crown-Root Ratio.—The reduction of an adverse crown-root ratio is frequently discussed in connection with, and as a part of, the restoration of the occlusal plane. The crown-root ratio is the proportion between the clinical crown and clinical root, and it is important in the resistance against the leverages of oral forces. When the length of an extruded tooth is reduced so that its occlusal surface is adjusted to the correct occlusal plane, a more favorable ratio is created. Except for extruded teeth, however, any appreciable coronal reduction to correct the crown-

Fig. 3.—An extruded maxillary first molar. Pulp exposure is necessary if this tooth is to be retained and reduced sufficiently for the development of a harmonious occlusal plane.

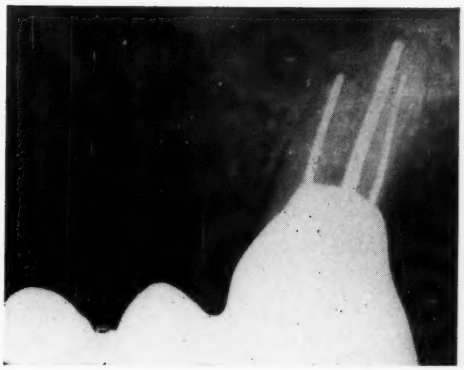

Fig. 4.—An endodontically treated second maxillary molar serving as the terminal abutment of a full arch fixed prosthesis. The tooth was badly extruded prior to tooth preparation and intentional pulp removal.

root ratio alone can be done only in the anterior part of the mouth. Very little reduction can be accomplished on posterior teeth. The main reason for this is found in the mechanics of jaw closure and the relationship of the anterior and posterior parts of the dental arch to the center of mandibular rotation. The nearer the tooth is to the condyle, the shorter will be its arc of closure and, consequently, the less distance it will travel in the closing movement. Because of this, a 1 mm. closure in the molar region may result in as much as a 3 mm. closure anteriorly (Fig. 5). Therefore, any effort to reduce the crown length of posterior teeth generally creates a problem anteriorly. This can lead to an unacceptable situation both esthetically and functionally. (The "open bite" occlusion would be an exception.) Anterior teeth, on the other hand, can be shortened within esthetic limits to effect a more favorable crown-root ratio (Fig. 6).

The restorative materials themselves impose an additional problem in decreasing the crown-root ratio. A crown restored on a prepared tooth is usually larger than the natural crown of the tooth had been. Enough tooth structure must be

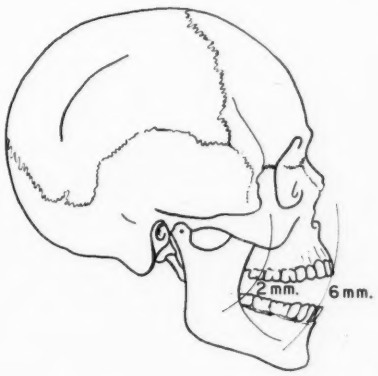

Fig. 5.—The smaller arc of closure in the second molar region as compared with the larger arc anteriorly results in a closure ratio of approximately 3:1 anteroposteriorly.

removed that the preparation can accommodate the materials used in the casting and facing. In order to reduce the coronal length, crowns may have to be overshortened, and intentional extirpation of vital areas may become necessary.

Obviously, a reduction in crown-root ratio is not indicated for all teeth. Also, when coronal reduction is indicated, pulpal recession may permit some latitude in the tooth preparation. Planned extirpation is suggested only where the alteration of the crown-root ratio is necessary and can be achieved in no other way. Pulp tissue is not sacrificed needlessly but is removed only in order to rehabilitate the remaining dentition more advantageously.

Establishment of Parallelism of Clinical Crowns.—In treating advanced periodontal disease, extensive splinting may be a necessary part of the treatment. Patients who need periodontal prosthesis seldom have a full complement of teeth, and none of them have an intact periodontium. Splinting has been used for these patients in an effort to stabilize the remaining affected teeth as well as to repair them and replace missing teeth. With the extensive splinting procedures (periodontal prosthesis), additional technical problems are introduced. Of these, achievement of parallelism of the prepared teeth is one of the most important and, at times, one of the most difficult problems to solve.

Fig. 6.—The mandibular incisor region shows the comparative lengths of the prepared and unprepared teeth. A greater incisogingival reduction is possible only with endodontic intervention.

In splinting, parallelism is an obvious prerequisite for seating the prosthesis. The longer the splint, the more involved this problem becomes. This is magnified to a greater extent by the indication for bilateral stabilization or splinting "around the arch." The long clinical crowns that result from supporting tissue destruction are of even more influence in the problem of paralleling preparations. The longer the crown, the longer the preparation and, consequently, the more difficult it is to obtain parallelism (Fig. 7).

The problems of parallel tooth preparation are not unique to periodontal prosthesis. They have long been known in restorative dentistry. Evidence of this is seen in the many gadgets available as aids for creating parallelism. Further proof lies in the various operative approaches introduced in an effort to circumvent this problem.

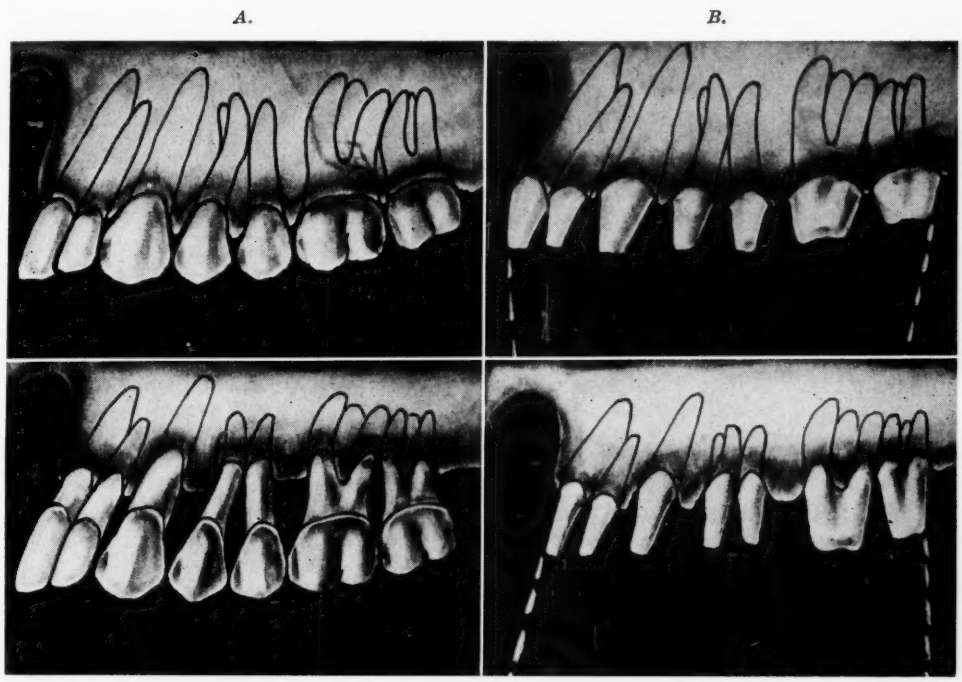

Fig. 7.—Comparison of the problem of attaining parallelism with normal periodontal support and with periodontally involved teeth. *A*, With the normal periodontium, the gingival tissue is at the cementoenamel junction and the underlying bone is at the normal level. *B*, The crown preparations are relatively short, and convergence or parallelism between labial surfaces of anterior teeth and distal surfaces of the terminal teeth is easily attained. *C*, With advanced periodontal destruction about the same teeth, the gingival tissue and bone are at a decreased level. *D*, The long crown preparations in a periodontally involved mouth. The problem of attaining parallelism becomes acute. Intentional vital pulp extirpation may become necessary to allow the placement of a splint. (From Amsterdam, M., and Cohen, D. W.: Restorative and Prosthetic Considerations in Periodontal Therapy.)

Fig. 8.—*A*, The unfavorable tooth inclination following periodontal therapy. The maxillary second premolar is inclined distally; the mandibular molars are tilted mesially. *B*, The pulp was removed intentionally from the maxillary premolar, and the tooth length was drastically reduced to create parallelism and a more favorable crown-root ratio. The pulp was removed from the mandibular second premolar to form a path of insertion parallel with the tilted molar teeth.

In any mouth, even one with minimal periodontal involvement, there are conditions contributing to the difficulty of attaining parallelism in preparations. Among these are the length of the span and the number and inclination of the teeth to be prepared. Effective measures for overcoming such difficulties are techniques of minor tooth movement, broken stress attachments, sectional splinting, and telescopic crowns. Also, the extirpation of vital pulps offers a most adaptable and useful method of solving the problem of parallelism. This is especially true when the teeth cannot be moved and when maximum rigidity of the appliance is desirable.

In preparation for a large splint, any grossly malaligned tooth will impose an obstacle. However, the regions which cause the greatest difficulty, and the regions that must be parallel or convergent, are the distal surfaces of the terminal teeth and the labial surfaces of the anterior teeth (Fig. 7). With an adverse inclination of teeth not amenable to minor orthodontic movement, extensive coronal reduction may become necessary to permit placement of the appliance. In accomplishment of this, pulpal involvement may ensue (Fig. 8). Endodontic therapy will then become necessary to retain the prepared tooth.

DISCUSSION

Consideration must be given to which tooth or teeth can best undergo intentional pulp removal in the treatment plan. The alignment of the individual teeth influences, but does not dictate, the teeth to be selected for pulp removal. The final selection is made after surveying the diagnostic casts and determining the relative difficulty of filling the teeth in question. The region selected should be the one which requires treatment of the smallest number of teeth in this manner, even though multirooted teeth may be involved.

The endodontic procedures may be carried out prior to or during the preparation of the crowns. An endodontic procedure that can be completed at one appointment is used with the usual precautions of endodontic therapy. The pulp is removed, and the canal is enlarged and obturated. Since there has been no prior bacterial invasion, intracanal antibacterial medication can be eliminated. Care should be exercised to avoid excessive instrumentation and overfilling.

These procedures are not to be regarded lightly or to be indulged in promiscuously. Extirpation of vital pulps should not be considered until other methods have been explored. On the other hand, extirpation affords a method of retaining teeth which otherwise would be indicated for extraction and a method of eliminating some of the technical problems of rehabilitation.

SUMMARY

Endodontics is recognized as an integral part of the treatment of patients with periodontal disorders. However, vital pulp extirpation seems to have been neglected. There seems to be a certain reluctance to admit to intentional pulpectomy, even among those who utilize the procedure. The feeling of guilt associated with the *intelligent, indicated* sacrifice of pulp tissue is no more justified than would be a similar feeling related to the removal of enamel and dentin in crown preparation.

Some of the indications for endodontic therapy in this context have been discussed. These include the restoration of a harmonious occlusal plane, the reduction of the crown-root ratio, and the establishment of parallelism. The necessity for intelligent treatment planning when vital pulp extirpation is considered has been stressed.

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MAXILLOFACIAL PROSTHESIS

MAXILLOFACIAL PROSTHETICS

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THE PROSTHETIC CORRECTION of maxillofacial defects involves mixed emotions. A great tragedy occurs in the life of a woman when a defective child is born to her. Next to this, probably one of the greatest heart-rending experiences is to see a loved one with an acquired facial deformity.

The study of maxillofacial defects should be divided into two parts, congenital and acquired.

CONGENITAL ANOMALIES

The more common congenital anomalies are cleft lip and cleft palate, defects of the limbs, muscular dystrophy, and mental retardation. Of these defects, clefts of the lip and palate and anomalies of the hands and feet can be overcome, that is, the individual can be habilitated to take his place in society. Cleft palate correction may be accomplished by surgical or prosthetic treatment, or both.

Etiology.—The etiology of congenital deformities is not well understood. The development of the embryo is very rapid. The nasal and oral cavities are beginning to form by the fifteenth day of embryonal development. By the thirty-fifth day, the mandibular processes unite to form the mandible, and the embryo is about ¼ inch in length. Between the sixtieth and sixty-third days, the anterior part of the palate closes and the closure normally continues distally. Fusion is complete by the sixty-third day, when the embryo is about 1⅓ inches long. The head represents about one-half the entire length of the fetus at this time. If for some reason there is a delay in the growth and development of the component parts of the maxillae, a cleft will result. Nature does not wait; the formative processes are continuous. Heredity cannot be ruled out as a causative factor, for a history of this defect in other members of the family is given in a large percentage of instances.

Some investigators have advanced the theory that there may be a mechanical factor in the cause, i.e., that it results from the position and pressures upon certain areas of the fetus. Diet can only be considered insofar as it leads to malnu-

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Read before the American Denture Society, Beverly Hills, Calif.
*Associate Clinical Professor, Denture Prosthetics.

trition. Mothers frequently give a history of having been badly frightened during the pregnancy. This should be discounted as a causative factor, however, for the fright usually occurred long after the time for normal closure.[1] Peer and associates[2] state: "It is probable that cortisone interferes with the metabolic functions of vitamin B_6 and folic acid, stimulates degenerative processes that nullify the effects of vitamins, or stimulates the metabolic alteration of the vitamins to forms that are inactive. The result of this interference is a retardation of the net rate of synthesis, probably proteins and nucleic acids, which are necessary for the growth of the embryo. If the hormone is administered to the mother at the time critical for palatal development, the gross result observed is the delivery of a high percentage of off-spring with cleft palates." This research was done on mice. It is not known what bearing this might have on human patients.

Related Problems.—When a cleft of the palate occurs, the integrity of the floor of the nasal cavity is partially or entirely missing. The problem arising from this condition are defective speech and deglutition, recurrent ear infections, loss of hearing, unesthetic appearance, and personality problems. The attitude of the parents toward the child's handicap may be the most significant factor in his own adjustment to the defect.

Correction of Cleft Palate Defects.—Cleft palate defects may be corrected surgically or by a prosthesis. Surgical closure is the first choice of treatment; it is usually done at a time prior to establishment of the speech pattern by the child.

A cleft of the lip is closed surgically soon after birth. Cosmetic surgical procedures are performed later if necessary.

The prosthetic treatment of cleft palate defects can be provided at any time, if the cooperation of the patient can be obtained. A thorough mouth examination should be made and a full history obtained before prosthetic treatment. The cleft should be classified as to extent, size, and mobility of the border tissues, both laterally and horizontally.[3]

Impressions.—Preliminary impressions are made in alginate impression material in a well-fitting impression tray. The final master impression is made in a custom-made acrylic resin tray. Alginate, silicone, or rubber-base impression materials may be used for the final wash impression over a border-molded modeling compound impression. The impression material must not be allowed to become locked in palatal perforations or undercuts in the mouth. Care must be taken to avoid aspiration of any of the impression material. Perforations and undercuts may be eliminated by the use of gauze impregnated with petroleum jelly or wet cellophane packed in the perforations. The lateral border tissues in a palatal cleft may be dense or flexible. Flexible tissues must not be distorted. The distal border of the impression must be built without a posterior palatal seal. The tissues at the distal end of the denture must be free to move and at the same time not displace the denture. When a complete denture is involved, the denture is finished before the impression of the cleft in the soft palate is made.[4] An impression of the cleft is made after the denture has settled into place with the border tissues in function. This impression is made with a wash material that remains workable for a long time. Impression wax or tissue treatment material* may be used for this purpose.

*Hydrocast.

These record detail and have sufficient working time to form the impression. This procedure takes about 2 hours. The impression is removed from the denture, processed, and reattached to it with screws. The screw heads are covered with cold-curing acrylic resin.

If the patient has most of the natural teeth, a prosthesis is built around or over those remaining. No tooth should be sacrificed unless absolutely necessary. If it is necessary, metal crowns should be placed over the remaining teeth to prevent loss through caries. These crowns are constructed with parallel sides to permit withdrawal of the restoration. Such obturators need a minimum of clasping; frequently, no clasps are used at all. Contact with two or more parallel walls provides adequate retention.

ACQUIRED ANOMALIES

Maxillofacial anomalies fall into two classes, combination (intra-extraoral) and facial (not involving the oral cavity). The facial anomalies may require either a surface or an embedded prosthesis.

Acquired maxillofacial anomalies may be due to injuries, such as gunshot wounds, or infections, such as syphilis and osteomyelitis. The surgical removal of malignant and associated tissues accounts for many facial anomalies. Also, perforations may result from irradiation therapy before and after surgical procedures.

Combination Anomalies.—The problems of function, comfort, esthetics, and personal satisfaction are insurmountable when the prosthesis rests upon movable tissue such as that around the oral cavity. Movements of the mandible, as in talking and chewing, will cause the margins of the prosthesis to loosen unless they are very thin. Thin margins deteriorate very rapidly and cause the prosthesis to become unusable.

The requirements and location of the defect determine the selection of the material of which the prosthesis is to be made. A rigid material is used for an intraoral prosthesis. The main part of the prosthesis may be modified by using a hinge attachment, flexible velum, or flexible material in the vicinity of the defects. Available materials are: (1) rigid—metals, vulcanite, porcelain, and acrylic resin; (2) semirigid—rubber, Teflon, Skin-tex, polyethylene, and Di-cor; (3) flexible—latex, Neoprene, Flexiderm, and high-bloom gelatin.

Orofacial prostheses are usually resorted to after surgical correction. At best they are poor substitutes for the lost tissue. They pose infinite problems of planning and construction. The use of a sectional impression is often necessary, and the prosthesis itself may have to be built in sections. The attachment may be by mechanical means or adhesives, or both. Any means for retention is acceptable if the purpose is accomplished.

Facial Anomalies.—

Surface prosthesis: The plug or collar button prosthesis is the simplest type. These appliances minimize the problem of retention, and the cosmetic problems can receive the major attention. A satisfactory working cast of the defective area must be obtained. A full head cast may be necessary. If the ears, eyes, mandible, or maxillary areas are involved, both sides of the face must be reproduced in the cast. Facial prosthesis most frequently needed is in the region of the nose and ears.[5,6]

The laboratory construction of these appliances is not difficult. From the esthetic standpoint, they are extremely difficult. Make-up plays a very important part in the effectiveness of facial prosthesis. Both the dentist and the patient must understand its value and application.

Embedded prosthesis: The embedded prosthesis is a form of implant. A surgical implant may be used in a reconstructive operation. The prosthodontist can advise and aid the plastic surgeon in matters pertaining to the design and fabrication of implant materials. Plastics and stainless metals, including tantalum, are used for this purpose. These implants are formed by casting or swaging the material to the desired form. Each patient presents problems peculiar to himself, and the technique used must be adapted to the existing conditions.

SUMMARY

1. Cleft lip and cleft palate patients can be habilitated by surgical or prosthetic treatment, or both.

2. The causes of these deformities have been discussed.

3. Adequate mouth examination and classification of cleft palate patients are necessary before construction of an obturator is begun.

4. The impression of a cleft in the soft palate region should be made after the basic complete or partial denture is completed.

5. A demountable distal (pharyngeal) extension enables the dentist to make the impression for the obturator when the border tissues are in function.

6. The obturator is processed independently of the denture and attached.

7. If natural teeth must be covered by an obturator, metal crowns should be placed on them to protect them from decay.

8. Natural teeth with full coverage are superior to a base with tooth crowns that protrude through openings in it.

9. Orofacial prostheses are a difficult type to construct, especially when flexible margins are necessary.

10. The art of applying make-up is an extremely important adjunct in orofacial prosthetics.

11. The dentist is an important member of the surgical team when embedded or implanted prostheses are required.

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BOOK REVIEW

ANATOMY AND PHYSIOLOGY OF SPEECH. By Harold M. Kaplan, Ph.D., New York, 1960, McGraw-Hill Book Company, Inc. 365 pages. $8.50.

This is an excellent book for students and teachers who are interested in phonetics and speech production. It is broad in scope and thorough, yet concise and clear. It presents the subject from the standpoint of several biologic disciplines which are masterfully integrated. Throughout the entire book, the author is ever mindful of correlating and, whenever possible, integrating the structure and function of all the organs that participate in sound and speech production. This is precisely the kind of approach that should be welcomed by the medical and dental professions, speech correction therapists, and all who are interested in the oronasolaryngopharyngeal structures in health and disease. This book is also of particular interest to those who are engaged directly or indirectly in cleft palate rehabilitation.

The content is excellently organized and interestingly presented. It is a very readable book, comprehensive in its treatment. Many areas in speech production mechanisms not well understood previously are elucidated.

Professor Kaplan has given us a most valuable addition to the literature on health services.

Joseph S. Landa, D.D.S

NEWS AND NOTES

MEETINGS

Australian Dental Association, 16th Australian Dental Congress, Sydney, New South Wales, Aug. 14 to 18, 1961.

Pacific Coast Society of Prosthodontists, Empress Hotel, Victoria, B. C., Aug. 31 to Sept. 2, 1961.

Eleventh Annual Instrument Symposium and Research Equipment Exhibit, Bethesda, Md., Oct. 9 to 12, 1961.

American Academy of Maxillofacial Prosthetics, Benjamin Franklin Hotel, Philadelphia, Pa., Oct. 11 to 13, 1961.

American Denture Society, Drake Hotel, Philadelphia, Pa., Oct. 13 and 14, 1961.

American Society of Dentistry for Children, 34th Annual Meeting, Bellevue-Stratford Hotel, Philadelphia, Pa., Oct. 13 to 15, 1961.

American Academy of Implant Dentures, Third Annual International Seminar on Implants in Dentistry, Philadelphia, Pa., Oct. 13 to 15, 1961. For further information and application write to Dr. A. Norman Cranin, Chairman, The American Academy of Implant Dentures, 2120 Ocean Ave., Brooklyn 29, N. Y.

The American Academy of Periodontology, 47th Annual Meeting, to be held on board the M. S. Bergensfjord sailing from Philadelphia on Oct. 20, 1961, to Bermuda and returning to Philadelphia on Oct. 25. For further information write to Caribbean Cruise Lines, Suite 301, Roeper Bldg., Miami 32, Fla., to the attention of Mr. E. M. Baskette.

The American Institute of Oral Biology, 18th Annual Meeting, Palm Springs, Calif., Nov. 6 to 10, 1961.

Greater New York Academy of Prosthodontics, Columbia University, New York, December, 1961.

ANNOUNCEMENTS

Reprints of the second edition of the *Glossary of Prosthodontic Terms* are now available. Prices: 1 to 20 copies, fifty cents each; 20 to 49 copies, forty cents each; 50 to 99 copies, thirty-five cents each; 100 or more copies, twenty-five cents each. Orders for less than 100 will be mailed prepaid; orders for 100 or more will be sent shipping charges collect. Cash, check, money order, or institution purchase order *must* accompany the order for reprints. Orders will not be filled otherwise. Address: Glossary Reprints, 3939 Old Brownsboro Road, Louisville 7, Ky.

Reprints of Reports Nos. 1 and 2, "Principles, Concepts, and Practices in Prosthodontics," may be obtained by writing Dr. W. Les Warburton, Secretary-Treasurer, Academy of Denture Prosthetics, 807 Medical Arts Bldg., Salt Lake City 11, Utah. The price is twenty-five cents for both, with a 20 per cent discount allowed on purchases of 20 or more. Cash, check, or purchase order *must* accompany the order.

NATIONAL DENTAL LABORATORY WEEK

National Dental Laboratory week will be observed Sept. 23 to 30, 1961. This week will be celebrated as part of the Tenth Anniversary of the National Association of Dental Laboratories, which is being observed this year, and will mark the "coming of age" of the ethical dental laboratories of the United States. National Dental Laboratory week will come just before the Annual Meeting of the NADL in Chicago, Oct. 3 to 7, 1961, at which the announcement of the new dental laboratory accreditation program being developed with the American Dental Association is expected to be presented.

In the 10 years of its history, the National Association of Dental Laboratories has been building closer liaison with the profession of dentistry in its service to the dental prescription or authorization, and this year is hoped to mark the culmination of a great deal of work, planning, and development which has included, in cosponsorship with the American Dental Association, the national program of certification for dental laboratory technicians.

Readers of THE JOURNAL OF PROSTHETIC DENTISTRY are invited to present lectures, projected conferences, table clinics, and demonstrations on any aspect of the field of dentistry before the Federación Odontologica de Centro América y Panamá, Jan. 21 through 26, 1962, in Panama.

For further information write to Dr. Alfredo H. Berguido, Apartado 4115, Panamá, República de Panamá.

The Philadelphia County Medical Society is establishing a library of health education literature for use by the public as well as physicians.

The library will consist of pamphlets and booklets on all health topics. These will include socioeconomic factors, health and safety, medical practice, diseases and disease control, and miscellaneous subjects in the health field.

In addition, the library will contain books on health education and educational techniques such as radio and television. Film catalogues and resource agencies for more material also will be included.

The public, science and medical students, physicians, and others in the health field will have access to the library, which will be located in the Medical Society's building at 301 South 21st St., Philadelphia, Pa. It will be used as a resource library for the Medical Society's speakers' bureau.

The library is being established through the efforts of the Medical Society's public relations committee, headed by Dr. Edward G. Sharp.

Contributions of pamphlets and resource catalogues for the library may be sent to Bette Metzler, Ball Associates Public Relations Agency, 845 North Broad St., Philadelphia 23, Pa.

FELLOWSHIPS AND GRADUATE STUDY

Loyola University, Chicago College of Dental Surgery, is offering a research and teacher training program in oral biology. This is under a teacher training grant from the National Institutes of Health. It is designed for candidates who desire a teacher's career in basic sciences or in clinical subjects. The stipends are up to $5,000 per year, and the program can lead to an advanced degree.

For further information and application write to Dr. Harry Sicher, Director, Loyola University, Chicago College of Dental Surgery, 1757 West Harrison St., Chicago 12, Ill.

Tufts University, School of Dental Medicine, announces two research fellowships in periodontology beginning September, 1961; also, three full-time graduate courses in periodontology.

For further information and application write to Dr. Irving Glickman, Periodontology, Tufts University, School of Dental Medicine, 136 Harrison Ave., Boston 11, Mass.

Boston University, School of Medicine, Division of Graduate Studies, Department of Stomatology, offers opportunities for graduate study in oral surgery, orthodontics, prosthetics, endodontics, and oral pathology. These courses are of 1 to 2 academic years' duration. For further information write to Department of Stomatology, Boston University, School of Medicine, 80 East Concord St., Boston 18, Mass.

The Graduate Division of the University of Washington, School of Dentistry, announces a graduate course in endodontics and microbiology leading to a master's degree in dentistry. The training period is 2 calendar years beginning September, 1961, and the course is designed to develop those men qualified and interested in a future in academic dentistry.

The trainee will be supported by a stipend of $5,300 per year from a National Institutes of Health teacher training grant. His tuition and some additional expenses will be paid as well as allowances for travel to scientific meetings.

The program is under the direction of Dr. John I. Ingle and includes advanced instruction in the basic sciences as well as the clinical and hospital disciplines. An extensive research project and thesis are required.

For further information and application write to Dr. Saul Schluger, Director, Graduate Dental Education, University of Washington, School of Dentistry, Seattle 5, Wash.

POSTGRADUATE COURSES

Boston University, School of Medicine, Division of Graduate Studies, Department of Stomatology, announces the following postgraduate courses:

Occlusal Adjustment: Dr. Bernard S. Chaikin, Dr. Henry M. Goldman, Dr. Gerald M. Kramer, Dr. William Pendergast, Dr. Irving Romanow, Dr. J. David Kohn, Dr. David J. Baraban, Dr. Leo Talkov, Dr. David V. Berry, and Dr. Jack Bloom, Oct. 30 to Nov. 3, 1961.

Periodontal Therapy: Dr. Henry M. Goldman, Dr. Bernard S. Chaikin, Dr. Gerald M. Kramer, Dr. William Pendergast, Dr. Irving Romanow, Dr. Jack Bloom, and associates, Nov. 6 to 10, 1961.

Endodontics: Dr. Herbert Schilder, Nov. 13 to 17, 1961.

Fixed Bridge Prosthesis: Dr. Leo Talkov, Dr. David J. Baraban, and Dr. Lloyd Warshauer, Nov. 27 to Dec. 1, 1961.

Periodontal Pathology: Dr. Henry M. Goldman and Dr. Jack Bloom, Jan. 22 to 26, 1962.

The Use of Ultrasonics in Periodontal Therapy: Dr. Henry M. Goldman, March 17, 1962.

Periodontal Therapy: Dr. Henry M. Goldman, Dr. Bernard S. Chaikin, Dr. Gerald M. Kramer, Dr. William Pendergast, Dr. Jack Bloom, and associates, March 19 to 23, 1962.

For further information write to Director of Postgraduate Studies, Department of Stomatology, Massachusetts Memorial Hospitals, 750 Harrison Ave., Boston 18, Mass.

New York University announces courses for 1961-1962 to be given in fixed partial prosthesis and in complete oral rehabilitation. Both courses involve practical chair work, lectures, and demonstrations. "Fixed Partial Prosthesis" utilizes elastic impression materials. The course will be given on Friday afternoons for 16 weeks beginning January, 1962, by Prof. Edward G. Kaufman.

"Complete Oral Rehabilitation" will be given every Friday for 32 weeks beginning October, 1961. The course covers full mouth treatment utilizing axis registrations and detailed occlusal study. Enrollment is limited, and acceptance is made only after personal interview. Instructors are Prof. David H. Coelho, Prof. Eugene A. Rothschild, and Prof. Albert Zola.

For further information and application write to Director, Postgraduate Division, New York University, College of Dentistry, 421 First Ave., New York 10, N. Y.

The University of North Carolina, School of Dentistry, announces the following postgraduate courses:

Dentistry for Children I, July 10 to 14, 1961.

Dentistry for Children II, July 17 to 21, 1961.

Dentistry for Children III, July 24 to 28, 1961.

For further information and application write to Office of Postgraduate Dental Instruction, University of North Carolina, School of Dentistry, P. O. Box 750, Chapel Hill, N. C.

The Ohio State University, College of Dentistry, announces the following postgraduate courses:

Complete Denture Prosthodontics: Dr. Carl O. Boucher, Oct. 2 to 6, 1961.

General Anesthesia: Dr. Morgan L. Allison, Nov. 13 to 17, 1961.

Oral Surgery: Dr. Morgan L. Allison, Nov. 27 to 29, 1961.

Hospital Management for Dental Procedures: Dr. Morgan L. Allison and Dr. Bernard S. Snyder, Jan. 22 to 24, 1962.

Clinical Periodontics: Dr. John R. Wilson and Dr. William V. Walton, Jan. 25 to 27, 1962.

A Refresher Course in Dental Hygiene: Dr. Consuelo Wise and Dr. John R. Wilson, Jan. 29 and 30, 1962.

Crown and Bridgework: Dr. Thomas F. McBride and Dr. Alfred C. Long, Jan. 31 to Feb. 2, 1962.

Pedodontics and Interceptive Orthodontics: Dr. Lyle S. Pettit and Dr. Benjamin H. Williams, Feb. 5 to 9, 1962.

Complete Denture Prosthodontics: Dr. Carl O. Boucher, Feb. 26 to March 2, 1962.

Removable Partial Denture Prosthodontics: Dr. Victor L. Steffel, March 5 to 9, 1962.

For further information and application write to the Ohio State University, College of Dentistry, 305 West Twelfth Ave., Columbus 10, Ohio.

The University of Pennsylvania, School of Dentistry, announces the following postgraduate course:

Orthodontics for the General Practitioner, Dr. Robert E. Moyers and associates, July 10 to 14, 1961.

For further information and application write to Director of Postgraduate Courses, University of Pennsylvania, School of Dentistry, 4001 Spruce St., Philadelphia 4, Pa.

Yeshiva University, Albert Einstein College of Medicine, Department of Dentistry, announces the following postgraduate courses:

Periodontics: Dr. Irving Yudkoff, Dr. Marvin N. Okun, and associates, Oct. 30 to Nov. 3, 1961.

Advanced Oral Pathology: Dr. Ernest Baden and associates, 3 consecutive days during December, 1961.

For further information and application write to Director, Postgraduate Dental Division, Yeshiva University, Albert Einstein College of Medicine, Eastchester Rd. and Morris Park Ave., Bronx 61, N. Y.

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